COOPERATIVE NATIONAL PARK RESOURCES STUDIES UNIT
UNIVERISTY OF HAWAI'I AT MANOA

Department of Botany
3190 Maile Way
Honolulu, Hawai'i 96822
(808) 956-8218

Technical Report 125

THE DISTRIBUTION AND ABUNDANCE OF LAND SNAILS IN THE NATIONAL PARK OF AMERICAN SAMOA, WITH PARTICULAR FOCUS ON PARTULIDAE

Robert H. Cowie[1] and Robert P. Cook[2]

[1]Department of Natural Sciences
Bishop Museum
1525 Bernice Street
Honolulu, Hawai'i 96817

[2]National Park of American Samoa
Pago Pago, American Samoa 96799

Cooperative Agreement

NPS CA 8028-2-9004

October 1999

Contribution No. 1999.001 of Bishop Museum's Pacific Biological Survey

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. EXECUTIVE SUMMARY

The native land snail faunas of Pacific islands are highly diverse and exhibit high levels of endemism. However, they are under serious threat from habitat destruction, predation by non-native predators, and competition from introduced alien species. Notably threatened are the highly publicized tree snails in the family Partulidae.

The American Samoan fauna includes 42 indigenous (native) land snail species (tree snails and ground-dwelling snails), 12 nonindigenous land snail (and slug) species, and six cryptogenic species (species whose status as native or alien is unknown). Of the 42 native species, more than 50 % are either single island or archipelago-specific endemics, that is, not found anywhere except in the Samoan archipelago.

The National Park of American Samoa contains a significant proportion of the remaining relatively pristine native forest in American Samoa and, as habitat alteration continues outside the Park, forest protected inside the Park will take on greater value. Because of this, the Park's is potentially an important refuge for threatened native land snails. Prior to the survey reported here, however, little was known about the Park's snail fauna: which species were present, how abundant they were, where did they occur within the Park.

Surveys were therefore undertaken (March, May, October, 1998) to ascertain the distribution and abundance of all species of land snails (and slugs) present in all three units (Tutuila, Taū, Ofu) of the Park. All land snail and slug species, native and alien, were recorded, but with particular effort focused on the partulid tree snails.

Of the 42 previously known native land snail species in American Samoa, the survey recorded 18 species, plus two unidentified species that probably belong in this category. Also recorded were 11 non-native species and three cryptogenic species that had been previously recorded in American Samoa. In addition, five previously unrecorded native species (including two undescribed) were found, and four non-native species were recorded for the first time. The known island by island distributions of 16 species previously recorded from one or more islands of the archipelago were extended. Notable absences in the survey were species of Endodontidae and Charopidae, which were thought to have already become extinct.

A major part of the fauna is composed of alien species. However, by far the most abundant species was the native arboreal *Pleuropoma beryllina* (family Helicinidae), which occurred on Tutuila and Ta'ū. Excluding this species leaves an overall proportion of specimens of native to alien (including cryptogenic) species of 59 % to 41 %. Specifically on Tutuila, 57 % are native; on Ta'ū, 55 %; and on Ofu, 68 %.

Among the relatively well known and conspicuous Partulidae, notable findings were that *Samoana abbreviata* (Tutuila endemic) is not extinct as previously thought, though it remains extremely rare; *Samoana conica* (Tutuila endemic) and *Eua zebrina* were more common than expected, though they have declined dramatically in the last 20 years or so;

and the extremely rare *Samoan thurstoni* (Ofu endemic) was recorded still alive at two locations. The newly recorded presence of *Eua zebrina* on Ofu is extraordinary. Unfortunately on Ofu, these partulids were only found outside the Park. No partulids are known from Ta'ū and none was recorded.

Few clear patterns of distribution emerged. On Tutuila, partulids were concentrated in the central area of the Park (Toa ridge, Faiga ridge, and eastwards to the Vatia powerline trail and as far as Tofu stream, and along Alava ridge from the radio towers to the top of the Vatia powerline trail and a little beyond), though the most abundant populations of *Eua zebrina* and *Samoana conica* were at Amalau. There are hints that this central area may harbor the greatest land snail diversity in the Tutuila unit. On Ta'ū, a number of species were confined to high elevations; others were only found at low elevations. This was also the case on Ofu, but the limited sampling on Ofu makes the interpretations very tentative.

Overall, the majority of native species for which an assessment is possible seem to be declining, based on comparisons in particular with surveys of 1975 and 1992. One native species (*Diastole schmeltziana*) may be increasing. For others there is no obvious trend.

Serious threats to the American Samoan land snail fauna remain (alien predators, alien competitors, habitat destruction and modification). Some species are probably extinct and others may well be very close to extinction. However, partulids, at least, are not as close to extinction as feared, and preservation of viable populations of these and other native snail species may still be possible, particularly within the protected habitats of the National Park. Recommendations to counter the threats and help the Park achieve its faunal preservation goals regarding the native snail fauna include:

Partulids. Conduct additional survey work on Ofu to ascertain the distributions of *Samoana thurstoni* and *Eua zebrina* on that island. Evaluate the feasibility of extending the Ofu unit of the Park to include populations of these two species. On Tutuila, curtail or severely limit development/habitat alterations in the central area in which partulids are most widely distributed, and the area of high abundance at Amalau.

Protection from predators. Eradication of rats and the introduced predatory snail *Euglandina rosea* from the Park is probably not feasible, but it may be possible to establish small managed areas from which these predators are excluded. As yet, *E. rosea* has only been recorded on Tutuila and Ta'ū. Strenuous efforts should be made to prevent it being introduced to Ofu and Olosega. It would likely be introduced if the giant African snail, *Achatina fulica*, were introduced to these islands. Preventing the introduction of *A. fulica* is therefore most important. The voracious predatory flatworm *Platydemus manokwari*, another putative control agent for *A. fulica*, should not be permitted to be introduced to American Samoa. The National Park should be at the forefront of actions in support of these endeavors by providing information and offering expert opinion.

Habitat modification. Traditional use of the Park will continue, but Park authorities must be alert to increased use, especially agricultural (plantation) encroachment farther into the

Park. Feral pigs constitute one of the most serious agents in the modification of native habitats. The goal of the Park's pig control program should be eradication. Generally increased activity in the Park will lead to increasing introduction of alien plants. Every effort should be made to prevent this.

Development. While the Park is mandated to develop access to and interpretation of its resources, it must do this in ways that least impact those resources. The Park should pursue its plan for developing the route from Fagasa pass to Alava mountain as a hiking trail only, limiting vehicular access. Present vehicular use and road maintenance activities result in erosion and increased spread of alien plants. Trail development from Alava mountain eastward will pass through the center of partulid snail distribution on Tutuila. Public trail development should be limited in this area to one trail from Alava mountain down to the village of Vatia via the existing powerline trail ("Historic Vatia trail"). Partulid populations along developed trails in this area should be carefully monitored, before and after trail development.The impacts of development in the Amalau inholding should be carefully monitored and efforts made to minimize it. On Ta'ū, if any trails are developed, potential impacts, notably habitat modification should be minimized.

Monitoring. Continued monitoring should permit reliable evaluation of trends in snail populations, which could then form the basis of management decisions for the Park that incorporate these important invertebrates. Monitoring must be simple and quick. Annually, selected snail species should be recorded at a small number of selected stations, following the same quantitative techniques as used in the survey here reported. This combination of selected species and stations could then be used as an indicator of the status of snails in the Park. More detailed monitoring every five years would provide information for species and stations not included in the annual monitoring and permit a more accurate evaluation of overall trends. Populations of partulids and of *Trochomorpha apia* should be monitored more comprehensively as they may be more susceptible to threats, especially development.

GIS and databases. All survey data (including data from the survey reported here) should be databased and incorporated into the Park's GIS program. Evaluation of patterns, including patterns of changing distribution and abundance, could then be monitored efficiently, and parts of the Park that are particularly pristine and/or rich in biodiversity could then be more accurately targeted for special attention.

Endangered species listing. All species reported here should be reevaluated by both the USFWS and the IUCN. The Park should support these efforts.

Education. Crucial to all the above efforts is increasing public awareness of the unique biota of the Samoan archipelago and the major role the National Park has to play in its conservation More specifically, and given that there will be some level of development and probably increased public use of the Park, users of the Park should be clearly informed of the importance of not disturbing plants and animals and of not introducing alien plants. The issue of native snail declines, and the role of partulid snails in Samoan folk crafts should be incorporated into interpretive programming.

2. BACKGROUND AND SCOPE

2.1. The land snail fauna

The native land snail faunas of Pacific islands are noted for their high diversity and high levels of endemism (Cowie, 1992, 1996a, b; Solem, 1976, 1983). They are also noted for being under severe threat from human activities including habitat destruction and introduction of alien predators (Civeyrel & Simberloff, 1996; Cowie, 1992, 1998a; Gargominy *et al.*, 1996; Hadfield, 1986; Hadfield *et al.*, 1993). Many nonindigenous snail species are being introduced, replacing the native species, and leading to a homogenization of land snail faunas across the Pacific and more widely (Cowie, 1998a, b, in press).

The land snail fauna of the Samoan archipelago is no exception. As recognized in a recent comprehensive nomenclatural catalog of the Samoan snails and slugs (Cowie, 1998c), there are 94 native land snail species. Of these 94 species, 59 are endemic to the archipelago, with 34 of these 59 recorded from only single islands. Extensive habitat destruction has taken place, especially on Tutuila, 'Upolu and Savai'i; introduced rats have been reported predating snails (Miller, 1993); and the predatory snail *Euglandina rosea*, as well as other predatory snails, has been introduced in ill-conceived efforts to control the introduced giant African snail, *Achatina fulica* (Cowie, 1998c). Cowie (1998c) listed 18 species of nonindigenous snails and slugs in the Samoan archipelago, most of them widespread synanthropic species.

Compared to the faunas of other archipelagos (notably the Hawaiian islands, which have over 750 endemic species), the native Samoan fauna is rather poor (Cowie, 1996b). However, the faunas of many island groups have not been adequately cataloged and it is not possible to enumerate them accurately. The Hawaiian islands are probably exceptional and the Samoan fauna should not be considered of minor significance, especially as many of its species are endemic. Reasons for different levels of diversity in different island groups in the Pacific are only just beginning to be understood (e.g., Cowie, 1996b).

The Samoan archipelago is divided politically into American Samoa and Samoa (formerly Western Samoa). This report is concerned with American Samoa, although some information about Samoa is provided for context. Cowie (1998c) listed 42 indigenous (native) land snail species explicitly recorded from American Samoa, and 12 nonindigenous land snail (and slug) species (some records of which were only tentative). An additional six species that were listed should be considered "cryptogenic" (i.e., status as native or alien is unknown; Carlton, 1996). Of the 42 native species, 15 are known only from American Samoa (endemic to American Samoa), with 13 of these 15 known only from single islands (endemic to single islands).

Notable among the fauna are the Partulidae. This family of tree snails is represented on most of the high volcanic islands of the Pacific, except the Hawaiian islands (Cowie, 1992). In general, they are single island endemics. They are the subject of a major program in evolutionary biology research that has recently begun to incorporate the Samoan

species (e.g., Cowie, 1992; Johnson *et al.*, 1993; Bryan Clarke and colleagues, personal communication). Cowie (1998c) listed eight partulid species in the Samoan islands, in two genera, *Eua* and *Samoana*, with five of these eight found in American Samoa and four of them endemic to American Samoa. Three species were listed as endemic to Tutuila (*Eua zebrina*, *Samoana abbreviata*, *S. conica*), as was a subspecies (*semilineata*) of a species otherwise found only on 'Upolu and Savai'i (*Samoana canalis*). The validity and true identity of this subspecies deserve further study but it is not considered further in this report. Ofu has a single endemic species, *Samoana thurstoni*. No partulids have been reported from Ta'ū or Olosega. In 1994, the U.S. Fish and Wildlife Service (USFWS) listed all the partulid species of American Samoa as candidates for listing as endangered or threatened (USFWS, 1994). With subsequent changes in USFWS procedures, only *Eua zebrina* remains as a candidate species, the other species are now considered "species of concern". The World Conservation Union (IUCN) also listed them in its *1996 Red List of Threatened Animals* (IUCN, 1996).

These numbers and distributions of species, derived from the catalog of Cowie (1998c), are not definitive, because the catalog was based only on published literature, although on a comprehensive review of that literature. Further research may lead to some of the species listed in the catalog being synonymized, thereby reducing the total numbers of recognized species, but undoubtedly new species remain to be discovered and the island by island distributions of species already known remain to be further elucidated. Additional survey work (for example, as reported herein) and study of museum collections will be necessary to accomplish this.

Much additional information about all the Samoan species of nonmarine snails and slugs, native and not, including a comprehensive bibliography, is available in the catalog (Cowie, 1998c). A field guide is being developed that will appear in both hard copy and on the Web (Cowie, in preparation).

2.2. Historical survey work and collections

The history of survey work and the scientific description of the native Samoan land snail species began soon after westerners encountered the islands. Many of the early descriptions were published by Augustus Addison Gould and Albert Mousson in the mid nineteenth century. Gould's material derived from the United States Exploring Expedition (1838–42). Mousson's species were largely based on material from the Museum Godeffroy in Hamburg, derived mostly from the collecting efforts of Édouard Graeffe. Other early authors of note who described significant numbers of Samoan taxa include Lovell Reeve, Louis Pfeiffer and William Harper Pease (see Cowie, 1998c).

In 1926 C.M. Cooke, Jr., A.F. Judd, and T.T. Dranga of the Bishop Museum (Honolulu) undertook extensive collecting of land snails on Tutuila, Aunu'u, Ta'ū and Ofu that resulted in acquisition of approximately 40,000 specimens in 2,440 lots (Gregory, 1927).

Wray Harris (in 1928 and 1937) collected predominantly on Ta'ū, but also on Ofu, Olosega, Tutuila, 'Upolu, and Swains. His collections (almost 4,500 lots) now constitute the largest single part of the Bishop Museum's holdings of Samoan land snails, and represent the largest single collection of Samoan material ever made.

From this time until the 1960s limited collecting of land snails was done in American Samoa, and no extensive surveys were undertaken. Notable collections were made, however, by R.T. Abbott (in 1940) (see Cooke & Kondo, 1961, e.g., p. 187).

In 1965 Alan Solem and Laurie Price of the Field Museum (Chicago), under a National Science Foundation grant, surveyed 40 stations on Savai'i and 'Upolu (see Girardi, 1978). The material from this survey is held at the Field Museum.

In 1967 Cooke's successor at the Bishop Museum, Yoshio Kondo, undertook extensive survey work on 'Upolu and Savai'i, but did not collect in American Samoa. His collections are held at the Bishop Museum.

In 1975 Laurie Price, under an Office of Endangered Species grant to Alan Solem, surveyed a total of 20 stations on Tutuila, Ofu and Ta'ū (Solem, 1975). The conservation status of the species recorded was assessed. The material from this survey is held at the Field Museum.

In 1992 a team led by Dr. Stephen E. Miller (USFWS), and including the first author of this report (Dr. Robert H. Cowie), as well as Barry D. Smith, a land snail specialist from the University of Guam, and Nora Rojeck, a graduate student from the University of Hawai'i, undertook brief survey work on both Tutuila and all three of the Manu'a islands (Ta'ū, Olosega, Ofu) (Miller, 1993; Miller *et al.*, 1993). The focus was on partulids, with the express intention of assessing the impacts of recent hurricanes and of introduced predators on these tree snails. Few partulids were seen and at only a small number of survey locations. Live partulids were not collected, being considered too seriously threatened, but a few collections of other species were made, and these collections are now held at the Bishop Museum.

In 1993 and 1994 staff of the Western Samoa (now Samoa) Department of Lands, Surveys and Environment, notably Anthony C. Robinson, undertook surveys predominantly in (Western) Samoa but also to a limited extent in American Samoa. Some of their material has been deposited at the Bishop Museum.

Incidental collecting work by a number of individuals (e.g., Pepper Trail in 1992 and 1993) has been undertaken during the 1990s, but these collections and data are not available.

2.3. The National Park of American Samoa and the rationale for the 1998 survey

The National Park of American Samoa was authorized by the U.S. Congress in 1988 and legally established in 1993. It is located on three islands: the Tutuila unit on the north side of the island extending from the main ridge down to the ocean and encompassing 7.5 % of the land area of Tutuila; the Ta'ū unit encompassing much of the southern and eastern parts of the island and including the highest point, Lata mountain (total 48.2 % of the land area of the island); and the Ofu unit, established primarily for the offshore coral reef but including a thin strip of land along the south shore of Ofu and including part of Sunuitao peak (4.0 % of the land area of Ofu) (Figure 1). The Park encompasses a total of 16.6 % of the land area of American Samoa. Much additional information is available in the Park's General Management Plan/Environmental Impact Statement (GMP/EIS) (Ainu'u *et al.*, 1997).

Much of the information about land snails in the GMP/EIS is, however, seriously incomplete. Apparently, it was derived from the report of Miller (1993), apparently considering that report to have listed the entire fauna of American Samoa, whereas in fact it only listed species found during the brief 1992 survey (see above). Nevertheless, the GMP/EIS clearly notes the decline of native snails in American Samoa, the threats posed to the remaining fauna, especially within the Tutuila unit of the Park, and the fact that most of the species listed by the USFWS in 1994 as "candidate" species for listing, have been recorded from within or in the vicinity of the Park. At present, with the change in USFWS procedures, only two of these species are formally listed as candidates, the others now treated as "species of concern".

Pacific island land snails have received considerable media attention as their populations decline and species go extinct (e.g., Gould, 1991; Murray, 1989; a recent BBC TV documentary). Most species are narrow endemics, often found only on single islands, sometimes confined to particular parts of an island (Cowie, 1996a, b). They are one of the better known examples of the biodiversity crisis that is overtaking many invertebrate species. And they constitute an important part of invertebrate biodiversity in the Park. As such, and given that the Park potentially harbored a number of especially threatened and vulnerable endemic species, and that Park authorities knew little about either the presence of many of these land snail species in the Park or their distributions, the survey work reported herein was implemented. The Park's GMP/EIS explicitly recognizes this lack of information regarding invertebrates in the Park. Therefore, the primary objective of the survey was to document the distribution and relative abundances of land snail species in as much of the Park's three units as possible, a recommendation also made for the land snails by Whistler (1992, 1994) in his botanical inventories of the Park. A secondary objective was to focus particularly on the distribution and abundances of tree snails in the family Partulidae (all listed by both USFWS and IUCN), as previous work (Miller, 1993) had suggested that these species were especially threatened, and possibly close to extinction, with at least one species probably extinct. The information resulting from the survey is important in the management of snail populations in the Park.

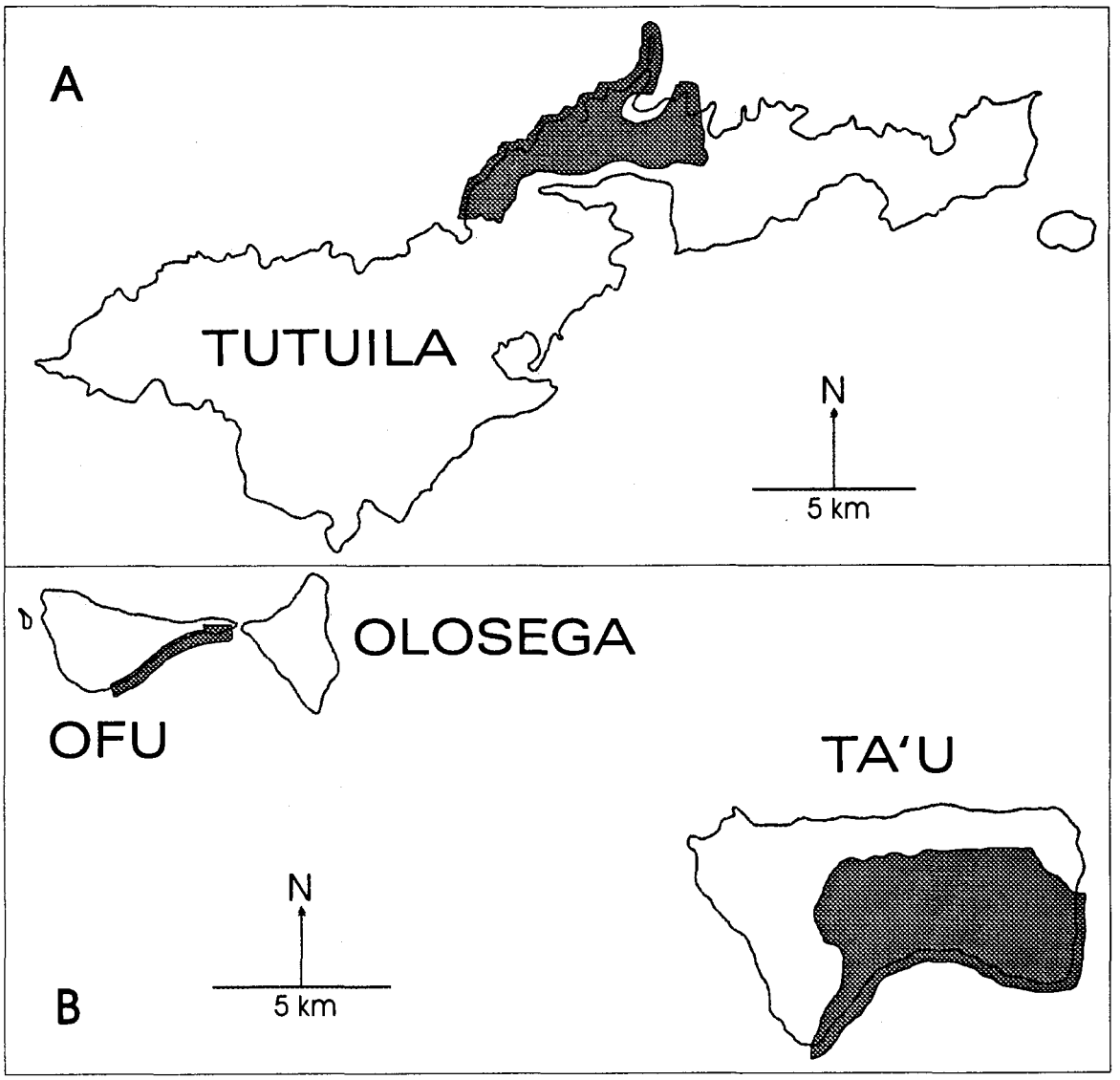


Figure 1. The three units (hatched areas) of the National Park of American Samoa. A—Tutuila; B—the Manu'a islands. The islands lie between 169° and 171° E and between 13° and 14° S. The Manu'a islands lie approx. 100 km east of Tutuila.

3. METHODS

Three two-week field trips were undertaken, the first and third to Tutuila, the second to the Manu'a islands. Material was collected and preserved in the field, and returned to the Bishop Museum for sorting, identification and analysis. Report preparation was done at the Bishop Museum.

3.1. Tutuila

3.1.1. Transects and sample stations

The Alava/Maugaloa ridge forms the backbone of central Tutuila and constitutes the southern boundary of the National Park. A series of ridges runs from this main ridge to the ocean, and many of these ridges have trails running down them. Fourteen ridges were selected, which constituted transects, mostly running north-south, as follows (Figure 2): 1—Siufaga point trail; 2—Lalofutu point trail; 3—Fagatuitui cove trail; 4—Plantation ridge; 5—Muliulu point trail; 6—Leemo ridge; 7—Pagatatua ridge; 8—Levaga ridge; 9—Maatulua ridge; 10A—Toa ridge; 11—Vatia powerline trail ("Historic Vatia trail"); 12—Faiga ridge; 13—Sauma/Tiatauala ridge; 14—Olo ridge. These transects broadly covered the entire Tutuila unit of the Park. Sampling stations were at intervals along the transects, four to six per transect, spaced so as to fairly evenly cover the elevational range of the transect. At least one sample was taken within each 100 m elevational interval. Precise location of stations was by reference to detailed topographical maps and by use of altimeters. Elevation was determined as the average of the readings from two altimeters, when two were available. However, although the altimeters were zeroed at sea-level at the start of every day, both tended to give somewhat different readings, which were not consistent. In addition, pressure changes during the course of a day meant that altimeter readings were sometimes highly inaccurate by the end of the day (as much as 100 m). The recorded elevations are therefore only approximate.

In addition to these fourteen transects, each of which included a single station at or a few meters below the point where the transect met the main ridge, an additional series of stations was sampled eastwards along the main ridge from the radio tower (Alava mountain) along Maugaloa ridge to the top of Olo ridge (transect 10) (Figure 2). A further three stations were sampled near the coast at Amalau (transect 14A).

These fourteen ridge-top to ocean transects plus the main ridge-top series of stations and the three stations at Amalau constituted the main, quantitative faunal survey. Additional stations were sampled opportunistically as snails were noticed.

Additional survey routes, numbered 11A, 11B, 12A, 13A, 13B, 14B (Figure 2), were investigated primarily to assess the distribution of Partulidae and *Trochomorpha apia* (see below, section 3.1.3.), which were not collected but only recorded. Opportunistic samples of other species were taken along these routes.

Locations of all stations on Tutuila are shown in Figure 3. Details of these stations are given in Appendix 1. Field notebooks are archived at the Bishop Museum.

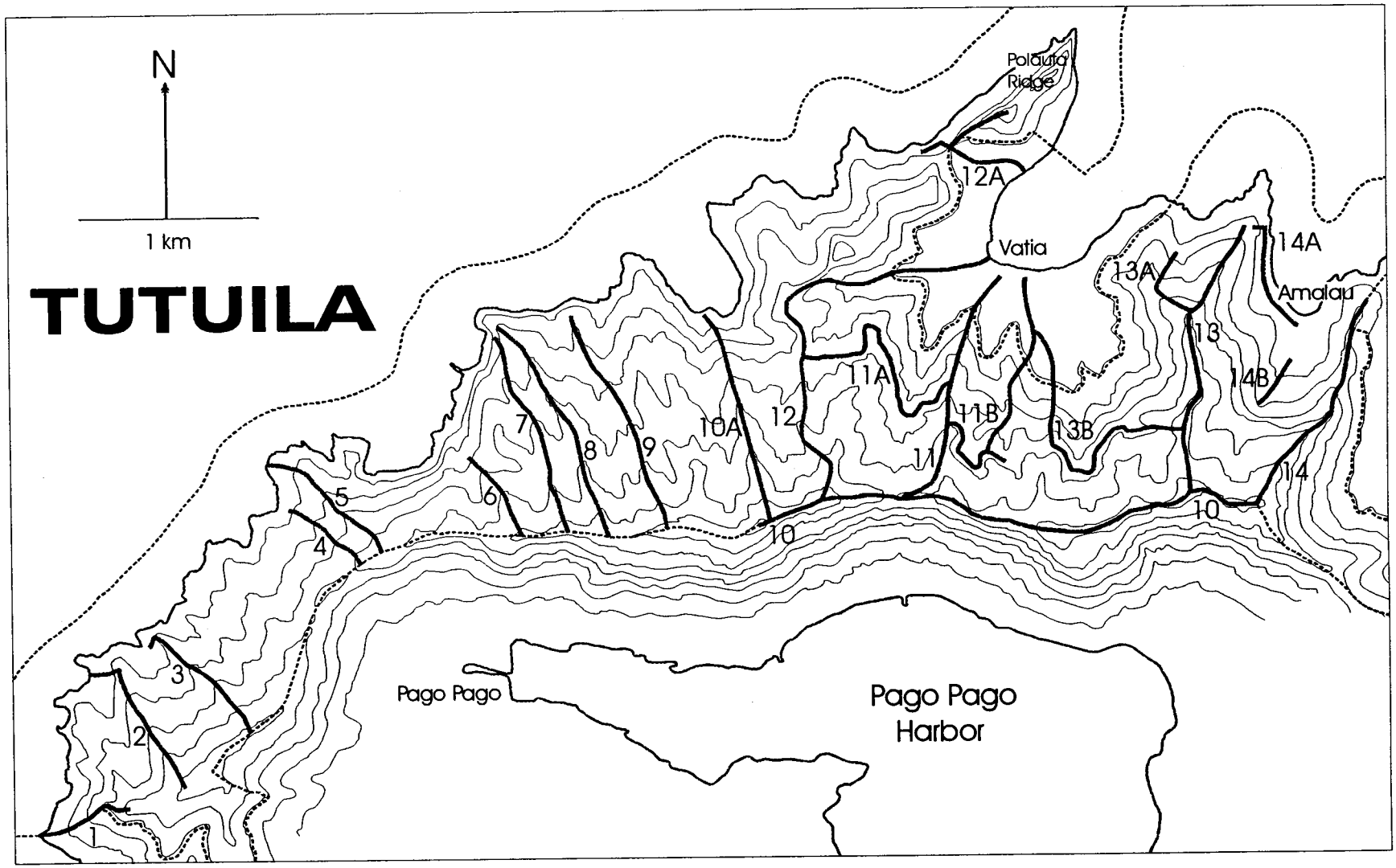


Figure 2. The 1998 survey area in the Tutuila unit of the National Park of American Samoa. The bold, numbered lines are the transects and survey routes (see text). The dotted line is the approximate boundary of the National Park. Contours are at 61 m (200 ft) intervals.

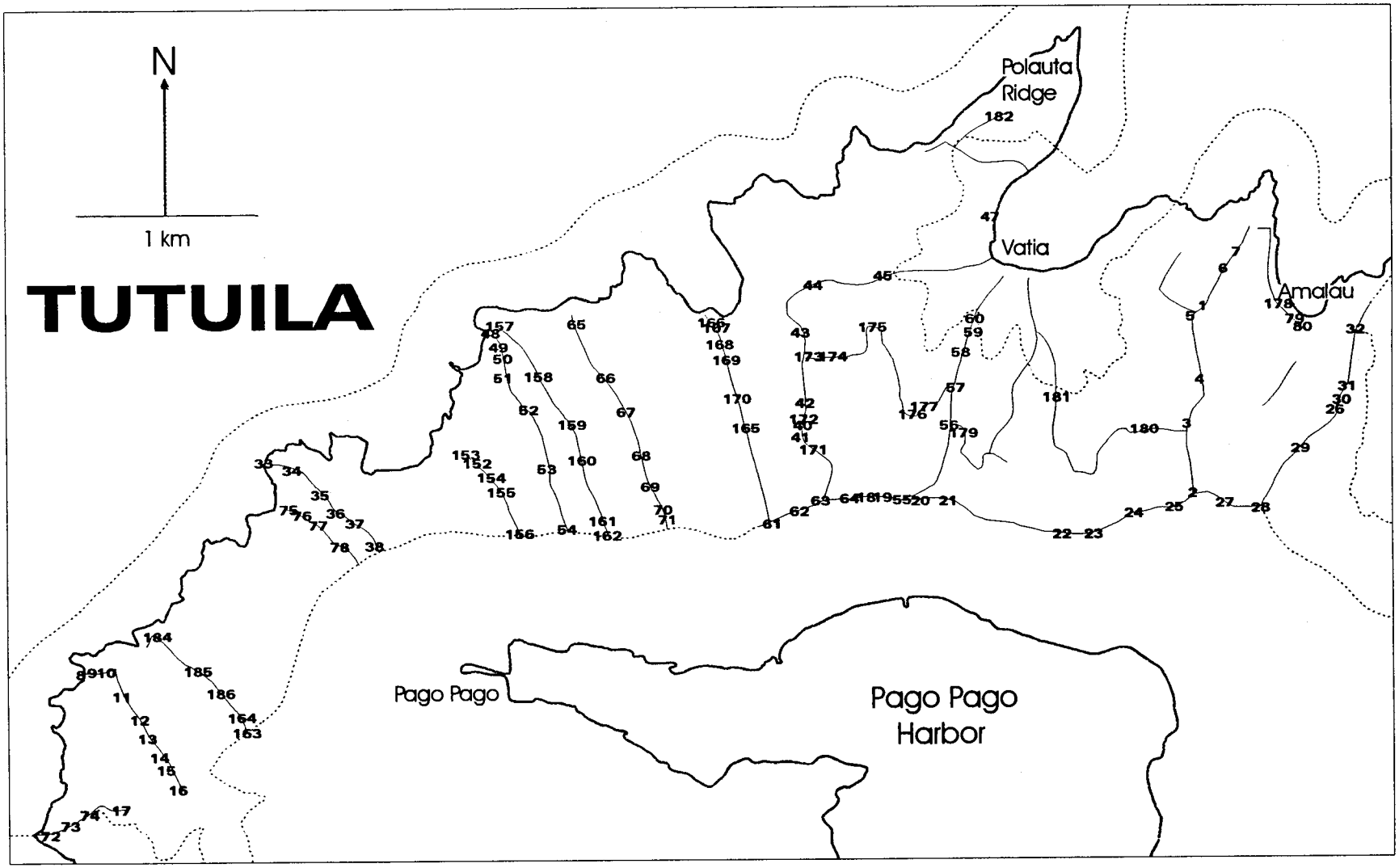


Figure 3. Location of numbered stations (stations numbers omitting the "98" prefix) along transects and survey routes in the Tutuila unit of the National Park of American Samoa. The dotted line is the approximate boundary of the National Park. Contours are at 61 m (200 ft) intervals.

3.1.2. Sampling and sample preservation

Sampling took place 3–16 March and 6–16 October 1998. At each of the main survey stations, separate samples were taken from vegetation and from the ground. Randomized quadrat sampling, that is, collecting all snails in a pre-determined, randomly identified fixed area, is inappropriate for land snails, especially small ones such as many of those that constitute the Samoan fauna, because of their extremely localized micro-distribution patterns. Instead, timed sampling, collecting all snails found in a fixed time within a relatively broadly circumscribed area (at a number of places within the area identified by an experienced individual as likely to harbor snails) has generally been found to be more appropriate (e.g., Cowie *et al.*, 1995; Emberton *et al.*, 1996) and was the approach adopted in this survey. Over an area in no case more than 50 m in diameter, three people (occasionally two, four or five) searched the vegetation for 20 min, an additional person searching the vegetation for 10 min and the ground for 10 min. [In a small number of instances these times differed, for pragmatic reasons; details are given in Appendix 1.] All snails were collected. All except live partulids and live *Trochomorpha apia* (see below) were retained as vouchers. Live snails were drowned by immersion in water for 24 hr, then preserved in 70 % ethanol. All collected material was returned to the Bishop Museum (Honolulu) for sorting and identification by comparison with the museum's extensive Samoan collections, including holotype and paratype material, and by reference to appropriate literature. A total of 87 stations was sampled in this manner.

In addition to this quantitative sampling program, opportunistic samples (25) were taken as snails were noticed. [Four additional samples were taken but were from freshwater (98.39, 98.46, 98.188) and marine habitats (98.183) and are not part of the land snail survey reported here. One terrestrial sample, from Tafuna (98.187), is also not part of the survey.] All specimens are held at the Bishop Museum.

3.1.3. Partulids and *Trochomorpha apia*

Because of the probable precarious status of partulids and *Trochomorpha apia* (Miller, 1993), only empty shells of these species were retained. At the main quantitative survey stations all snails were collected, but once the numbers of partulids and *T. apia* had been recorded these snails were released by placing them back in the vegetation. (A small number of partulids were inadvertently collected and retained.) The status of the partulids as adult or juvenile was recorded.

Opportunistic samples were taken when empty partulid shells were seen on the ground. In addition, all live partulids seen alongside the trails were recorded.

The main objectives of the October 1998 field trip to Tutuila (in addition to completing the ridge-top quantitative surveys) were 1) to access areas between the ridges, particularly in areas where partulids had previously been found on the ridges, and 2) to generally investigate areas not surveyed during the March 1998 field trip, to obtain a more complete picture of the distribution of partulids in the Park. In most cases there were no trails in

these areas. Quantitative samples were generally not taken; rather, all partulids and *Trochomorpha apia* that were seen by the survey team while slowly progressing through the forest were recorded, but not collected. Other species were also recorded if they were considered notable. The areas surveyed in this manner are shown in Figure 2 as numbered survey routes, as follows: 11A from Faiga ridge to the Vatia powerline trail, approximately along the 215 m [c. 700 ft] elevation contour; 11B from the Vatia powerline trail almost to Matavalu ridge, approximately along the 290 m [950 ft] contour, then down across Matavalu ridge to Faatafe stream; 12A from Vatia up to the saddle between Polauta ridge and Siuono ridge, up Polauta ridge, and from the saddle down to the shore on the northwest side of the ridges and along the coastal forest to the west; 13A up Vaiola stream to the crest of Tiatauala ridge then up Tiatauala ridge to the Sauma/ Tiatauala ridge trail; 13B from Sauma/Tiatauala ridge westward, approximately between the 260 m [850 ft] and 305 m [1,000 ft] contours, to the ridge between Tofu and Faatafe streams then down the ridge to join up with 11B along Faatafe stream; 14B up the stream above Amalau to the point where the stream forks, with waterfalls on each fork.

3.2. Manu'a

3.2.1. Areas surveyed and sample stations

The topology of the Manu'a islands did not permit series of parallel transects to be established as on Tutuila. On Ta'ū (Figure 4) samples were taken at spaced elevational intervals along the trails that were accessible, including a newly broken trail to the top of Lata mountain. Additional samples were taken at low elevation. On Ofu (Figure 5), where the National Park is established predominantly as a coral reef park, samples were taken along the coast and on Sunuitao peak (within the Park), but also outside the boundaries of the National Park both north of Sunuitao peak and along the track to the top of Tumu mountain.

3.2.2. Sampling and sample preservation

Sampling took place 29 April–6 May 1998 on Ta'ū and 7–9 May 1998 on Ofu. The sampling and preservation protocols were the same as were followed on Tutuila (above, section 3.1.2.), except that on Ofu at a number of coastal stations no vegetation samples were taken (98.134–98.136, 98.138, 98.147), and also on Ofu at one station (98.143) a number of partulids were deliberately collected as vouchers representing a new island record for the species (see below, section 4.1.2.). On Ta'ū 41 stations were sampled quantitatively, and an additional 10 opportunistic samples were taken. [Two additional samples were taken but were from marine (98.99) and freshwater (98.105) habitats and are not included in the land snail survey reported here.] On Ofu 17 stations were sampled quantitatively; one additional opportunistic sample was taken. Details of sampling stations are given in Appendices 2 (Ta'ū) and 3 (Ofu), and field note books are archived at the Bishop Museum. All specimens are held at the Bishop Museum.

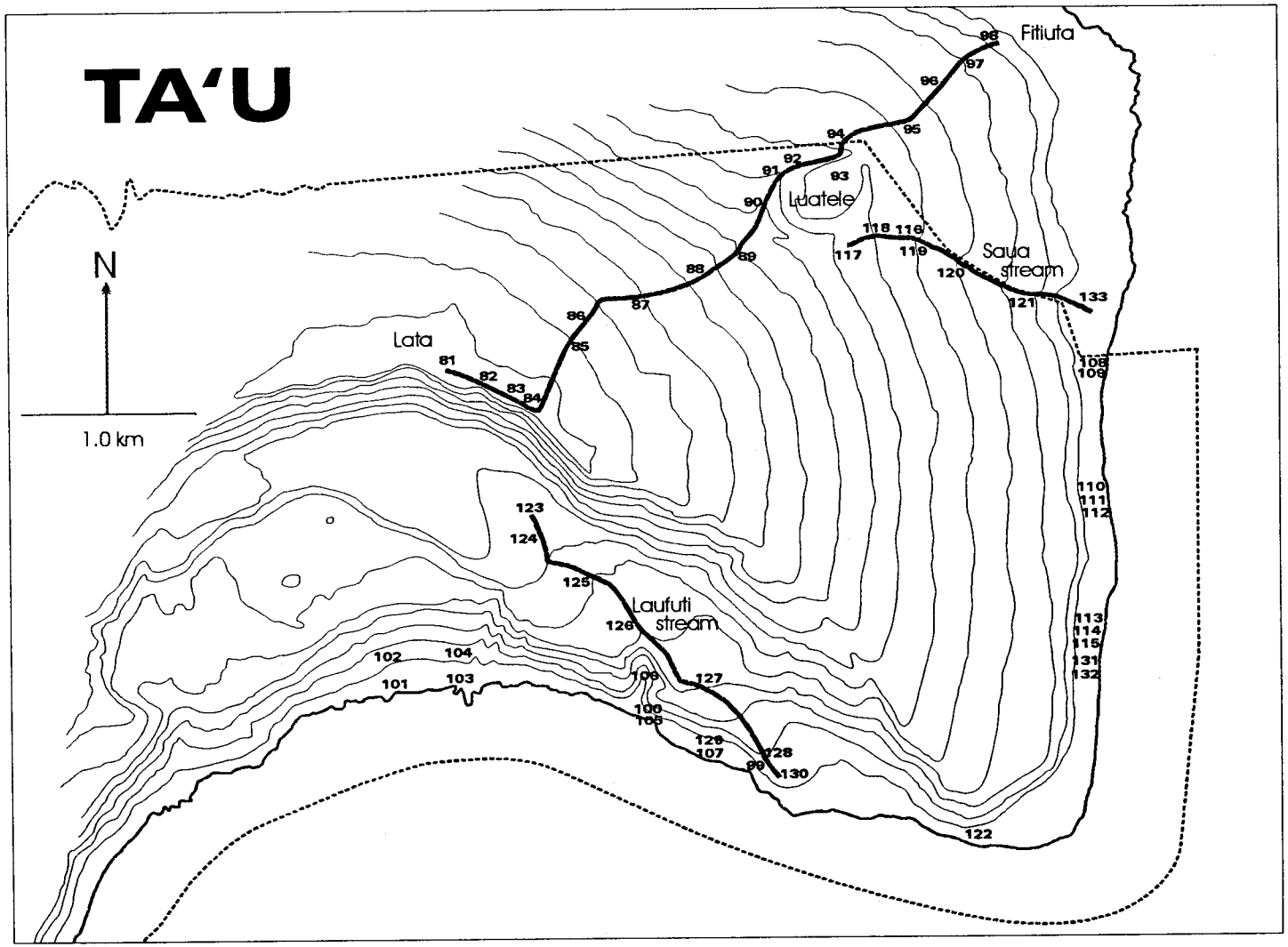


Figure 4. The 1998 survey area in the Ta'ū unit of the National Park of American Samoa. Bold lines are the non-coastal survey routes. Numbers indicate the sampling stations (omitting the "98" prefix). The dotted line is the approximate boundary of the National Park. Contours are at 61 m (200 ft) intervals.

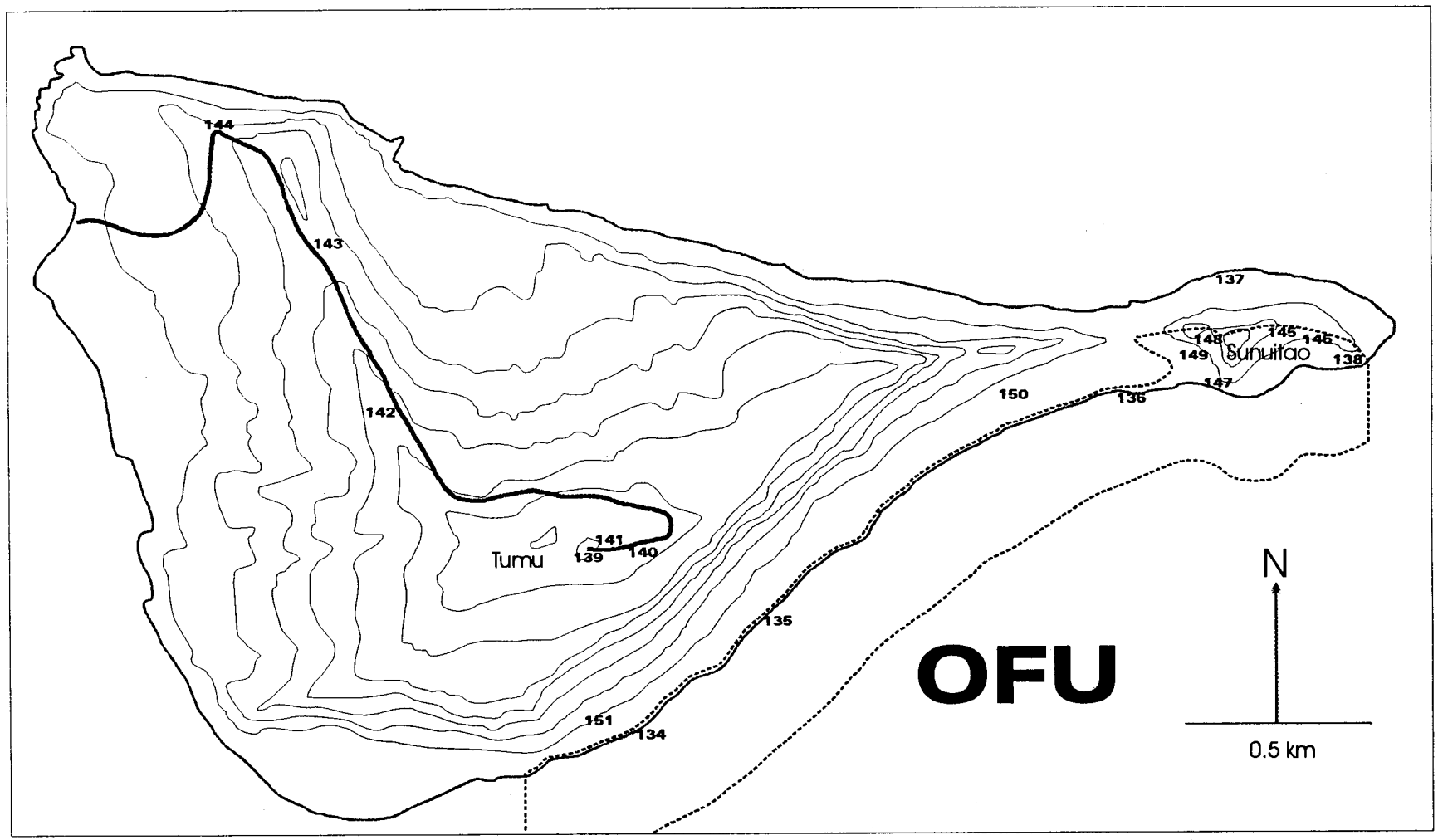


Figure 5. The 1998 survey area in the Ofu unit of the National Park of American Samoa. The bold line is the survey route to the top of Tumu mountain (see text). Numbers indicate the sampling stations (omitting the "98" prefix). The dotted line is the approximate boundary of the National Park. Contours are at 61 m (200 ft) intervals.

4. RESULTS

4.1. Species recorded, with assessments of their conservation status

4.1.1 Overview

Table 1 gives summary statistics for the survey, indicating the amount of time spent, the total number of specimens and species collected/recorded and a breakdown of the numbers of native species (including partulids), alien species, and "cryptogenic" species (i.e., species whose origins, native or alien, are unknown; Carlton, 1996).

Of the previously known 42 indigenous species (occur naturally in the Samoan archipelago) occurring in American Samoa (Cowie, 1998c), 19 were recorded during the survey. Of the previously known 12 nonindigenous species (deliberately or accidentally introduced by humans) occurring in American Samoa (Cowie, 1998c), 11 were recorded during the survey. Three of the six previously recorded cryptogenic species were also recorded during the survey.

In addition to these species previously known from American Samoa, a number of additional species were recorded for the first time. These were: three described species that are presumed to be native (*Truncatella guerinii*, *Tralia costata*, *Melampus castaneus*), one of them (*Tralia costata*) being a new record for the archipelago but all being widespread in the Pacific and inhabiting the high upper shoreline; four nonindigenous species (*Laevicaulis alte*, *Vaginulus plebeius*, *Lamellaxis micra*, *Ovachlamys fulgens*), the latter two being new records for the archipelago; and one cryptogenic species (?*Pronesopupa* sp.). Two undescribed and presumed endemic species (*Pleuropoma* n. sp., *Diastole* n. sp.) are also new records for the archipelago.

Of the 24 native species recorded during the survey (19 previously recorded, five new), ten are endemic to the Samoan archipelago (others may be endemic but are too poorly known). Of these ten species, two are also known from (Western) Samoa, one is known only from Tutuila and Ofu, two are endemic to Tutuila, three are endemic to the Manu'a islands (but found on more than one island, including the undescribed species of *Diastole*), one (the undescribed species of *Pleuropoma*) is endemic to Ta'ū, and one is endemic to Ofu.

The known island by island distributions of 16 species previously recorded from one or more islands of the archipelago were extended. These 16 species included six native, nine alien, and one cryptogenic species.

A major part of the fauna is composed of alien species (Table 1). However, by far the most abundant species was the native *Pleuropoma beryllina*, which occurred on Tutuila and Ta'ū and heavily dominated the arboreal snail fauna. Excluding this species (5,940 specimens) leaves a balance of 3,516 specimens of native species and 2,419 specimens of alien plus cryptogenic species, a ratio of 59 % native to 41 % alien/cryptogenic.

Table 1. Summary statistics for the 1998 survey.
Days represents the total number of days x individuals (person-days) spent in the field (excluding days spent in inter-island travel and excluding rest days). Hours represents the total number of hours x individuals (person-hours) spent actually searching for snails at quantitatively sampled stations only. Much additional time was spent searching along the trails and survey routes (notably for partulids). Specimens represents the total number of specimens collected or recorded at the numbered sample stations (quantitative and opportunistic) but excludes those (mostly partulids) simply recorded alongside the trail that were not part of the numbered series. Native species include those that occur naturally in the Samoan archipelago (endemic and indigenous); cryptogenic species are species of unknown origin (native or alien). Note that total species numbers differ from the sum of the island totals because some species occur on more than one island. The unidentified veronicellids and unidentified *Omphalotropis* are assumed to belong to one of the species recorded and are not counted as additional species in this table.

	Stations		Time		Specimens			Species		
	quantitative	opportunistic	days	hours	native	alien	cryptogenic	native	alien	cryptogenic
TUTUILA	87	25	99	125	7,029	1,321	198	18	11	2
TA'Ū	41	10	34	58	1,485	427	21	15	6	1
OFU	17	1	15	26	942	437	15	16	8	3
TOTALS	145	36	148	209	9,456	2,185	234	24	15	4

Specifically on Tutuila, these figures are 2,033 (57 %) native and 1,519 (43 %) alien/ cryptogenic; on Ta'ū, 541 (55 %) and 448 (45 %); on Ofu, 942 (68 %) and 452 (32 %).

4.1.2. Species accounts

Table 2 lists the species recorded in the 1998 survey with details including island by island distributions, abundances, and an assessment of their conservation status. The numbers of each species found at each station, both live snails and empty shells, are given in Appendices 4 (Tutuila), 5 (Ta'ū) and 6 (Ofu). Details of observations of partulids (*Eua zebrina, Samoana abbreviata, S. conica, S. thurstoni*) that were not part of the quantitative, station-based survey are given in Appendix 7. Details of incidental observations of other species are given in Appendix 8. Maps, one for each species on each island, illustrating their distributions, are given in Appendix 9.

Brief notes are now provided regarding each of the species. Additional information and references to additional relevant literature can be found in Cowie (1998c). The islands given following the species names are those on which the species were found during the 1998 survey. If they are also known from other islands this is indicated in the text. Following the island(s) is the species' status as endemic, indigenous (native but not endemic), alien, or cryptogenic in the Samoan archipelago. Other pertinent information is also provided.

Table 2. List of land snail and slug species recorded in the National Park of American Samoa during the 1998 survey.
For each species the following information is given: whether it was recorded alive or only as dead shells, whether live individuals were found predominantly on vegetation or on the ground, its status as endemic, indigenous, alien or cryptogenic in the Samoan archipelago, the island(s) from which it was recorded (T—Tutuila; Ta—Ta'ū; O—Ofu) and following the island abbreviation in parentheses the number of stations it was recorded from on that island (both quantitative and opportunistic), a subjective assessment of its current abundance (rare, common, abundant), and for endemic species a tentative assessment of conservation status (endangered, possibly endangered, not endangered). New records for the Samoan archipelago are asterisked; new island records are indicated by a dagger (†).Taxonomic arrangement and nomenclature follow Cowie (1998c). For further explanation see text.

Family and Species	Live/dead	Veg/ground	Status	Island(s) and number of stations	Abundance	Threat
HELICINIDAE						
Orobophana musiva (Gould, 1847)	live	veg/ground	indigenous	T(11), Ta(14), O(14)	common/rare	possibly endangered
Pleuropoma beryllina (Gould, 1847)	live	veg	indigenous	T(84), Ta(15)†	abundant	not endangered
Pleuropoma fulgora (Gould, 1847)	live	ground	indigenous	T(60), Ta(34), O(8)	common/rare	possibly endangered
Pleuropoma n. sp.*	live	veg	endemic	Ta(4)†	rare	possibly endangered
POTERIIDAE						
Ostodes adjunctus (Mousson, 1869)	dead only	-	endemic	T(2)	rare	endangered
TRUNCATELLIDAE						
Truncatella guerinii Villa & Villa, 1841	live	ground	indigenous	Ta(1)†, O(4)†	rare	-
ASSIMINEIDAE						
Assiminea parvula (Mousson, 1865)	live	ground	indigenous	T(10), Ta(2), O(2)	rare	-
Omphalotropis sp. A	live	ground	endemic/indigenous	T(8)	rare	possibly endangered
Omphalotropis sp. B	live	ground	endemic/indigenous	Ta(2)	rare	possibly endangered
Omphalotropis sp.	dead only	-	endemic/indigenous	O(1)	rare	possibly endangered
VERONICELLIDAE						
Laevicaulis alte (Férussac, 1822)	live	ground	alien	T(3)†	common/rare	-
Vaginulus plebeius Fischer, 1868	live	ground	alien	T(3)†	common/rare	-
Veronicellidae, unidentified	live	ground	alien	T(14)†, Ta(7)†	common/rare	-
ELLOBIIDAE						
Melampus castaneus (Megerle, 1816)	live	ground	indigenous	T(1)†, Ta(2)†, O(4)†	common/rare	-
Melampus fasciatus (Deshayes, 1830)	live	ground	indigenous	T(3), Ta(3), O(6)	common	-
Tralia costata (Quoy & Gaimard, 1832)*	dead only	ground	indigenous	T(1)†, O(1)†	rare	-
Pythia scarabaeus (Linnaeus, 1758)	live	ground	indigenous	T(2), Ta(9), O(4)	common	-

continued...

Table 2. continued.

Family and Species	Live/dead	Veg/ground	Status	Island(s) and number of stations	Abundance	Threat
ACHATINELLIDAE						
Lamellidea pusilla (Gould, 1847)	dead only	-	cryptogenic	O(1)	rare	-
Elasmias sp.	live	veg	cryptogenic	T(14), Ta (1), O(1)	common/rare	not endangered
PUPILLIDAE						
Pupisoma orcula (Benson, 1850)	dead only	-	cryptogenic	O(1)†	rare	-
?Pronesopupa sp.*	dead only	-	cryptogenic	T(1)†	rare	-
PARTULIDAE						
Eua zebrina (Gould, 1847)	live	veg	endemic	T(24), O(1)†	rare	possibly endangered
Samoana abbreviata (Mousson, 1869)	live	veg	endemic	T(8)	rare	endangered
Samoana conica (Gould, 1847)	live	veg	endemic	T(16)	rare	endangered
Samoana thurstoni (Cooke & Crampton, 1930)	live	veg	endemic	O(2)	rare	endangered
SUBULINIDAE						
Allopeas clavulinum (Potiez & Michaud, 1838)	live	ground	alien	T(20), Ta(11)†, O(3)†	common	-
Lamellaxis micra (Orbigny, 1835)*	dead only	-	alien	O(2)†	rare	-
Opeas hannense (Rang, 1831)	dead only	-	alien	O(2)†	rare	-
Paropeas achatinaceum (Pfeiffer, 1846)	live	ground	alien	T(69), Ta(25)†, O(10)†	common	-
Subulina octona (Bruguière, 1789)	live	ground	alien	T(69), Ta(24), O(14)	abundant	-
ACHATINIDAE						
Achatina fulica Bowdich, 1822	live	ground	alien	T(26), Ta(2)	common	-
SPIRAXIDAE						
Euglandina rosea (Férussac, 1821)	live	ground	alien	T(37)	common	-
STREPTAXIDAE						
Gulella bicolor (Hutton, 1834)	dead only	-	alien	O(3)†	rare	-
Streptostele musaecola (Morelet, 1860)	dead only	-	alien	T(1), Ta(1)†, O(3)†	rare	-
Gonaxis kibweziensis (Smith, 1894)	live	ground	alien	T(28)	common	-
RHYTIDIDAE						
Ouagapia gradata (Gould, 1846)	live	ground	indigenous	T(1), Ta(2), O(1)	rare	-

continued...

Table 2. continued.

Family and Species	Live/dead	Veg/ground	Status	Island(s) and number of stations	Abundance	Threat
SUCCINEIDAE						
Succinea manuana Gould, 1846	live	veg	endemic	Ta(8), O(9)	rare	possibly endangered
Succinea modesta Gould, 1846	live	veg/ground	indigenous	T(11)	rare	possibly endangered
HELICARIONIDAE						
Diastole schmeltziana (Mousson, 1865)	live	veg	endemic	T(31), Ta(5)†, O(3)	common	not endangered
Diastole n. sp.*	live	veg	endemic	Ta(4)†, O(2)†	rare	possibly endangered
Liardetia samoensis (Mousson, 1865)	live	ground	indigenous	T(3), Ta(3)†, O(2)	rare	-
Ovachlamys fulgens (Gude, 1900)*	live	veg/ground	alien	T(11)†	common	-
ARIOPHANTIDAE						
Parmarion martensi Simroth, 1893	live	ground	alien	T(9)	rare	-
ZONITIDAE						
Trochomorpha apia (Hombron & Jacquinot, 1852)	live	veg	endemic	T(1)	rare	endangered
BRADYBAENIDAE						
Bradybaena similaris (Rang, 1831)	live	ground	alien	O(1)	rare	-

In addition to this general information, the status (distribution and abundance) of each species is noted in terms of the numbers of stations at which they were found, any obvious pattern in the distribution of these occupied stations, and any other pertinent distribution/abundance information (notably for Partulidae). A tentative assessment of their conservation status is also given, if relevant.

HELICINIDAE

The taxonomy of the Samoan helicinids has been little studied and identification is extremely difficult. A main distinction is made here between keeled forms (shell sharply angled around the periphery), which are all referred to *Pleuropoma fulgora*, and forms lacking a keel, which are referred to *Orobophana musiva*, and tentatively to *Pleuropoma beryllina* and a possibly undescribed species (*Pleuropoma* n. sp.).

Orobophana musiva. Tutuila, Ta'ū, Ofu. Indigenous. This species has been recorded previously from Tutuila, Ta'ū, Ofu, and Olosega, as well as from Savai'i and 'Upolu; it has also been recorded from Fiji and Tonga (see Cowie, 1998c). It is small and usually possesses transverse zig-zag markings on its shell. Frequently, the shell also has rows of prominent periostracal hairs running in lines along the spiral of the shell; these hairs probably wear off with age. Comparison with type material from the U.S. National Museum of Natural History (Smithsonian Institution) (lot number 5509, probably the lectotype) confirms the identification of the present Samoan material, although the Smithsonian specimen is not hairy. It is possible that there are two species, one with hairs and one without, but resolving this issue requires intensive taxonomic work beyond the scope of this report.

Status. Solem (1975) reported this species from Ofu and Tutuila, but not from Ta'ū. He considered it as one of the widely distributed and presumably relatively common species. Miller (1993) recorded it at only one of the nine sites surveyed on Tutuila, but at all of the 8 sites surveyed on the Manu'a islands. During the 1998 survey it was found at 11 (alive at eight) of the 87 quantitatively sampled stations on Tutuila, at 11 of the 41 quantitatively sampled stations and 3 of the ten opportunistic stations (alive at four) on Ta'ū, and at 14 (alive at two) of the 17 quantitatively sampled stations on Ofu. It was never found in large numbers and most collected specimens were dead shells. It seems to be more common on the Manu'a islands than on Tutuila, as appeared also to be the case in 1992. It may be declining, but its status elsewhere in its range must be evaluated before it should be considered under threat on a world-wide basis.

Pleuropoma beryllina. Tutuila, Ta'ū. Indigenous. Cowie (1998c) only tentatively recorded this species from the Samoan islands, specifically from Tutuila. Correct identification of the present material is only tentative. Confident identification would require taxonomic research beyond the scope of this report. The material collected is very variable in shell color and patterning (though never possessing transverse zig-zag markings) but seems to belong nonetheless to just a single species. There are four possible taxa to which the material might be referred: *Pleuropoma beryllina*, *P. beryllina* var. *flavida*, *P. beryllina tutuilana*, and *P. jetschini*. *P. beryllina* var. *flavida* is only recorded

from Tutuila (Cowie, 1998c) and was established by Mousson (1869) for the yellow color forms. *P. beryllina tutuilana* was established by Wagner (1907–11) as the subspecies of *P. beryllina* on Tutuila. *P. jetschini* was established by Wagner (1905) as a species usually with colored banding on the shells. A syntype of *P. beryllina*, loaned from the U.S. National Museum of Natural History (Smithsoniam Institution) (lot number 5513, from Fiji), is, however, slightly larger than the present Samoan specimens. Nevertheless, all four taxa may be synonyms, and because *beryllina* is the oldest name, it is used provisionally for the present material. None of these four taxa has previously been recorded from Ta'ū.

Status. Solem (1975) recorded this species from Tutuila (as "*Pleuropoma beryllina flavida*"), considering it tolerant of "moderate degrees of habitat disturbance" and not in any immediate danger of extinction. In 1992 it was found at eight of the nine sites surveyed (alive at seven) on Tutuila (Miller, 1993). It was not recorded on the Manu'a islands during the 1975 or 1992 surveys. During the 1998 survey it was found on Tutuila at 83 (alive at 81) of the 87 quantitatively sampled stations and at one opportunistically sampled station (alive). On Ta'ū, it was found at 15 of the 41 quantitatively sampled stations. It was not found on Ofu. On Tutuila it was by far the most widespread and abundant snail. On Ta'ū it was abundant where it occurred but, with one low elevation exception (station 98.102), was only found at elevations above 300 m, which may be the reason it has not previosuly been recorded from Ta'ū, no previous snail surveys having investigated the higher elevation parts of the island. It is not under threat.

Pleuropoma fulgora. Tutuila, Ta'ū, Ofu. Indigenous. This species has been recorded previously from Tutuila, Ta'ū, Ofu, and Olosega, as well as from Savai'i and 'Upolu. It has also been recorded from Fiji (see Cowie, 1998c). On Tutuila and Ofu, it was almost invariably found on the ground in the leaf litter, whereas on Ta'ū it was also frequently encountered on the vegetation. Also, the snails from Ta'ū seemed slightly larger than those from Tutuila and Ofu. These observations may indicate that there are two distinct species, but resolution of that question requires intensive taxonomic research beyond the scope of this report; all specimens are therefore provisionally referred to *P. fulgora.*

Status. Solem (1975) reported this species from Tutuila, Ta'ū, and Ofu, considering it widespread and not threatened. Miller (1993) recorded it at five of nine sites surveyed on Tutuila and at three of eight sites on the Manu'a islands. During the 1998 survey, it was found at over 50 % of the stations, and on all three islands, although always in low numbers. Although this species remains widespread, it has almost certainly declined considerably in abundance, judging by the large numbers of specimens collected at single localities earlier in the century and now in the Bishop Museum collections. It deserves careful monitoring.

Pleuropoma n. sp. Ta'ū. Endemic. This species resembles *Pleuropoma fulgora* and *Orobophana musiva* in having transverse zig-zag patterns running across the whorls of the shell. However, it does not have a keel, the periphery of the shell being rounded as in *P. beryllina*, and it is larger than *O. musiva.* It is possibly an undescribed species.

Status. This species appears to be restricted to the highest elevations of Ta'ū, found at four stations only (98.81–98.84), and alive at all of them. This is probably why it has not

been recorded previously; because previous snail surveys on Ta'ū have only investigated low elevations. Whether it is declining or not cannot be evaluated but it deserves attention.

POTERIIDAE

Ostodes adjunctus. Tutuila. Endemic. The genus *Ostodes* is endemic to the Samoan archipelago (Girardi, 1978). Only two species are known from American Samoa, both confined to Tutuila. *O. adjunctus* occurs only in the eastern portion of the island; the other species (*O. strigatus*) occurs in the western part.

Status. In 1975 both species were considered common (Solem, 1975), but by 1992 *O. strigatus* was found alive at only one of the nine sites surveyed on Tutuila and was therefore considered to have declined; *O. adjunctus* was not reported (Miller, 1993). Only *O. adjunctus* would be expected to occur in the National Park. However, only two shells (empty) were found during the 1998 survey, one at each of stations 98.33 and 98.80. To ascertain whether this species is now as rare as this throughout its former range will require further survey work outside the National Park, but it should provisionally be considered highly endangered.

TRUNCATELLIDAE

Truncatella guerinii. Ta'ū, Ofu. Indigenous. These are the first records of this species from Ta'ū and Ofu; it was previously only recorded in the literature from Savai'i (Cowie, 1998c). It is probably to be found on all islands, as it seems to be widely distributed in the Indo-Pacific. Usually, and as in this survey, it is found under leaf litter and other debris close to the seashore, usually in sheltered places just above the high water mark.

Status. Neither Solem (1975) nor Miller (1993) recorded this species, and although it was only found during the 1998 survey at one station on Ta'ū (98.109) and four on Ofu (98.134, 98.136, 98.138, 98.147), and was not recorded on Tutuila, this probably all reflects limited sampling in its usual habitat. It is probably present on Tutuila. It is probably not threatened.

ASSIMINEIDAE

Assiminea parvula. Tutuila, Ta'ū, Ofu. Indigenous. This species has usually been referred to in the literature as *Assiminea nitida* (Pease, 1865), but this is a junior synonym (Cowie, 1998c). It is widespread in the Pacific. Unlike most assimineids, which are somewhat amphibious, it appears to inhabit entirely terrestrial, although damp, habitats and does not have a requirement for brackish water (cf. Abbott, 1958).

Status. Solem (1975) reported this species (as "*Assiminea nitida*") from Tutuila, Ta'ū and Ofu, considering it widespread and not threatened. In 1992 a species tentatively but probably correctly identified as *Assiminea parvula* (as "*nitida*") was also recorded from all three islands (Miller, 1993). During the 1998 survey it was again recorded on all three islands, but despite its ubiquity it was only sporadically encountered in the Park (11 stations on Tutuila [alive at five], two on Ta'ū, two on Ofu) and in very low numbers. However, it should not be considered threatened.

Omphalotropis sp. A. Tutuila. Endemic/indigenous. A number of species of *Omphalotropis* are known from the Samoan archipelago. However, comparison with synoptic material in the Bishop Museum collections did not permit a specific identification. However, the survey specimens from Tutuila do all belong to a single species and match closely to unidentified material from Tutuila in the Bishop Museum collections. Most specimens are characterized by one or often two ribs running spirally around the shell, which distinguish them from the also slightly broader sp. B (below). Most of the Samoan species of *Omphalotropis* are also recorded from elsewhere (e.g., Tonga, Uvea). Additional taxonomic research would be necessary to determine the true identity of this species (possibly undescribed) and whether it is endemic to the Samoan islands.

Status. Because of the uncertainty about its identity it is not possible to evaluate the overall status of this species. However, it was found, mostly in low numbers, at 11 stations (alive at three) out of the 87 that constituted the quantitative survey on Tutuila. In 1975 a species of *Omphalotropis* (identified, perhaps incorrectly, as *O. bifilaris teretiformis*) was found at only two of at least 14 stations on Tutuila (Solem, 1975); and in 1992 the same species as recorded here was recorded at two out of nine stations, neither in the National Park (Miller, 1993). The species is probably not declining and may not be in any danger. It may in fact be able to tolerate some level of disturbance, as other species of *Omphalotropis* have been seen in large numbers in highly disturbed habitats elsewhere in the Pacific (Cowie *et al.*, 1996).

Omphalotropis sp. B. Ta'ū. Endemic/indigenous. This species is very similar to *Omphalotropis* sp. A (above). It is approximately the same size, but the shell is slightly broader in relation to its height, and it lacks the two raised spiral ribs that characterize most of the shells of sp. A. Again, it does not match any named specimens in the Bishop Museum collections, although it does match unidentified material from Ta'ū, Olosega and Ofu. It also cannot be definitively identified, nor can its status as endemic or not be determined, without additional taxonomic research.

Status. As for *Omphalotropis* sp. A, it is not possible to evaluate the overall status of this species, because its true identity is not known. It was found at two stations (close to each other), alive at one, out of 41 sampled quantitatively on Ta'ū, and seemed abundant at these sites. In 1975 a different species, *O. conoidea* (assuming correct identification), was reported from at least one station on Ta'ū and was not considered under any threat (Solem, 1975). In 1992 no specimens of any species of *Omphalotropis* were recorded from the Manu'a islands (eight sites surveyed) (Miller, 1993). This species seems highly localized on the basis of the 1998 survey, but may be found to be more widespread if more intensive sampling is undertaken at low elevations. If it is an endemic Samoan species and is indeed extremely highly localized, it may be under significant threat.

Omphalotropis sp. Ofu. Endemic/indigenous. On Ofu (station 98.150.2) a single dead juvenile shell was found that cannot be identified to species. It probably belongs to either species A or B above, most likely species B.

Status. Neither Solem (1975) nor Miller (1993) reported any species of *Omphalotropis* from Ofu. It is not possible to elaborate further on the status of this species.

VERONICELLIDAE

Identification of veronicellids is extremely difficult, even for a veronicellid expert (to whom representative specimens from this survey were sent), and can only be achieved reliably by dissection of adults. Some of the present identifications remain tentative and previous records may have been incorrectly determined. Some specimens from the 1998 survey could not be identified to species and are listed simply as "Veronicellidae, unidentified" (below). The impacts of these veronicellids are unknown, but they are large animals with generalist feeding habits and can reach high population densities, so they may well be responsible for habitat modification and competition with native species.

Laevicaulis alte. Tutuila. Alien. This alien slug, thought to be of African origin, is now widely distributed through Asia and the islands of the Pacific (Cowie, 1997; 1998c). It has been tentatively reported from 'Upolu, but this is the first record from American Samoa. The identification also remains somewhat tentative.

Status. This species is probably more common in disturbed habitats at low elevation (not the focus of the 1998 survey). It has probably been in the Samoan islands for a long time, but simply not reported. Whether it will increase in abundance and become more widespread is not known; neither are its potential impacts known (but see above). It was found at three widely separate sampling stations (98.48, 98.60, 98.71) and recorded incidentally at an additional location (Olo ridge, see Appendix 8), all at relatively low elevations. However, it may well be more widespread if additional records of unidentified veronicellids (below) in fact represent this species.

Vaginulus plebeius. Tutuila. Alien. This neotropical alien slug is also widely distributed on Pacific islands, and in some places (e.g., the Hawaiian islands) may be replacing *Laevicaulis alte* (above) (Cowie, 1997). It has been reported from 'Upolu and tentatively from Savai'i (Cowie, 1998c), but this is the first record from American Samoa. It is often reported in the literature (e.g., Cowie, 1997) as "*Vaginula plebeia*" but this appears to be incorrect (Cowie, 1998c).

Status. As for *Laevicaulis alte*. It was found at three sampling stations (98.45, 98.48, 98.52) and recorded incidentally at two additional locations (at the junction of the Vatia powerline trail with Maugaloa ridge, where it was abundant, and on Olo ridge, see Appendix 8), ranging from low to high elevations. No doubt some of the additional records of unidentified veronicellids (below) in fact represent this species.

Veronicellidae, unidentified. Tutuila, Ta'ū. Alien. These records, including the first record of veronicellids on Ta'ū, almost certainly refer to one or other of the above two species, but their identity cannot be determined.

Status. As for the above two species. Perhaps veronicellids are relatively recent arrivals on Ta'ū, and may not yet have reached Ofu. Unidentified veronicellids were found at 14 stations on Tutuila and at seven on Ta'ū, widely scattered over the surveyed areas.

ELLOBIIDAE

Most species of Ellobiidae inhabit the upper shoreline or forest immediately adjacent to the shore. Sometimes they are referred to as "Melampodidae" (or "Melampidae") but this name refers to a subfamily within the Ellobiidae (Cowie, 1998c). In particular, species of *Melampus* are often extremely abundant. However, they are also very difficult to distinguish. The Pacific species of *Melampus* are in dire need of taxonomic revision and the present identifications of species in this genus are provisional.

Melampus castaneus. Tutuila, Ta'ū, Ofu. Indigenous. This species was formerly only recorded from 'Upolu and tentatively from Nu'utele and Nu'ulua (Cowie, 1998c). These are the first records of this species for American Samoa. It is probably on all islands because it is a widespread Pacific species. Specimens with a somewhat more squat shape and a relatively distinct angulation or shoulder at the periphery of the body whorl are here referred to this species (see Cernohorsky, 1972, pl. 60., fig. 6; Kay, 1979, fig. 157H). Many of these are yellow in color, and probably have been referrred to *Melampus luteus* by other authors, which may explain the lack of previous records of *M. castaneus* in American Samoa, but some specimens are deep purplish brown. None has spiral banding patterning.

Status. *Melampus castaneus* is widespread and common, although less so than *M. fasciatus* (below). The spotty distribution of the survey material (one station on Tutuila, two on Ta'ū, four on Ofu) reflects the sparse sampling of coastal habitats (especially on Tutuila). It is not threatened.

Melampus fasciatus. Tutuila, Ta'ū, Ofu. Indigenous. This species has been recorded from all the main islands of the Samoan archipelago, except explicitly from Olosega. Specimens with a slightly more pronounced spire and a rounder periphery are here referred to this species (see Cernohorsky, 1972, pl. 61, fig. 1b; Franc, 1957, fig. 90; Springsteen & Leobrera, 1986, pl. 81, figs. 16a, b). Frequently, these specimens possess spiral banding patterning. Generally they are smaller than those specimens referred to *M. castaneus*. Cernohorsky (1972) relegated *Melampus fasciatus* and *M. luteus* to "forms" of *M. flavus* (see also Springsteen & Leobrera, 1986) but *M. flavus* has not been recorded form the Samoan archipelago (Cowie, 1998c) and *M. fasciatus* is here retained as a valid name.

Status. *Melampus fasciatus* is widespread and common. The spotty distribution of the survey material (three stations on Tutuila, three on Ta'ū, six on Ofu) reflects the sparse sampling of coastal habitats (especially on Tutuila). It is not threatened.

Tralia costata. Ta'ū, Ofu. Indigenous. This is the first record of this poorly known species in the Samoan archipelago. It is probably to be found on all islands, as it seems to be widely distributed in the Pacific (Abbott, 1989; Cernohorsky, 1978). It was placed by Morton (1955) in the subfamily Melampodinae. Little appears to have been published about it, but Abbott (1989) reported it as "uncommon in shoreline debris on muddy earth" and Cernohorsky (1978) reported it as "moderately uncommon" and "under rocks, at the high tide level".

Status. This species seems to be widespread but uncommon in the Pacific. During the 1998 survey, a single empty shell was found at each of two stations: in typical habitat (98.147), and above the shoreline in coastal forest at an elevation of 17 m (98.101). It is probably not under threat in the Samoa islands, despite its apparent rarity (although suitable habitats were not extensively sampled during the 1998 survey).

Pythia scarabaeus. Tutuila, Ta'ū, Ofu. Indigenous. The taxonomy of the genus *Pythia* in the Pacific has not been well studied and the identity of the 1998 survey material may be questionable. Three species of *Pythia* have been recorded from the Samoan archipelago (Cowie, 1998c). *Pythia tortuosa* was recorded from 'Upolu in 1887; *Pythia savaiensis* was described in 1869 from material from Savai'i and Manu'a (no island specified); neither appears to have been recorded subsequently. *Pythia scarabaeus*, a morphologically somewhat variable species, is widespread throughout the Pacific. It is possible that both *P. tortuosa* and *P. savaiensis* are synonyms of *P. scarabaeus*, as hinted at by Martins (1995). Without further taxonomic research this question cannot be resolved, but the present material is tentatively referred to *P. scarabaeus*. This is a species of the coastal forest floor.

Status. *Pythia scarabaeus* is widespread and common. The spotty distribution of the survey material (two stations on Tutuila, nine on Ta'ū, four on Ofu) reflects the sparse sampling of coastal forest habitats (especially on Tutuila). It is not threatened.

ACHATINELLIDAE

Lamellidea pusilla. Ofu. Cryptogenic. This species is widespread in the Pacific, possibly in large part through human activites, including introduction by early Polynesian settlers (Cooke & Kondo, 1961). It has also been recorded from Tutuila, Ta'ū, Olosega, and Swains, as well as from 'Upolu (Cowie, 1998c). It is probably confined to lowlands, often in disturbed areas, on fallen leaves and stones on the ground.

Status. The Bishop Museum does not have large amounts of material of this species from the Samoan archipelago. It was not recorded in 1975 (Solem, 1975) or 1992 (Miller, 1993). Only a single empty shell was found during the 1998 survey (98.147), perhaps reflecting limited sampling in lowland, disturbed areas, but perhaps also reflecting a decline in abundance. This species may never have been especially common, and now seems rare. However, its status elsewhere in its range must be evaluated before it should be considered under threat on a world-wide basis.

Elasmias sp. Tutuila, Ta'ū, Ofu. Cryptogenic. Cooke & Kondo (1961) gave no records of *Elasmias* spp. from the Samoan archipelago, although their map (p. 220) included Samoa in the distribution of the genus, with the recorded distribution of one species, *aperta* Pease, 1865, extending from the Marquesas and Society islands to Rotuma and Tongatapu (p. 223). *Elasmias aperta* was probably transported widely by Polynesian voyagers (Cooke & Kondo, 1961; Solem, 1964). The Bishop Museum holds collections labeled *Elasmias* sp. from 'Upolu, Tutuila, and Ta'ū. Further taxonomic research would be required to identify the 1998 material to species. *Elasmias* spp. are arboreal.

Status. Solem (1975) did not report any species of *Elasmias*. The 1992 survey (Miller, 1993) recorded *Elasmias* sp. from two of nine sites surveyed on Tutuila, but did not record it from the Manu'a islands (8 sites). Although Miller (1993) did not identify it to species, it may be *E. aperta*. In 1998 *Elasmias* sp. was recorded at 26 of the 87 quantitatively sampled stations on Tutuila and at one on each of Ta'ū (98.131) and Ofu (98.150), alive at all of them. It therefore appears relatively common on Tutuila but rare on Ta'ū and Ofu, although there is no evidence for any decline, and it should probably not be considered under threat.

PUPILLIDAE

Pupisoma orcula. Ofu. Cryptogenic. This species is widespread in the Pacific and elsewhere, possibly in part as a result of human activities. Previously it had been tentatively recorded from Tutuila only (Cowie, 1998c), although there are a small number of shells from other Samoan islands in the Bishop Museum.

Status. A single dead shell was found during the survey (98.137) at low elevation on Ofu. This species was probably never abundant in American Samoa as there is rather little Samoan material in the Bishop Museum. It was not recorded in either 1975 or 1992 (Miller, 1993; Solem, 1975). It therefore must be considered rare in American Samoa, at least in the National Park, and may be declining. Its status elsewhere in its range must be evaluated before it should be considered under threat on a world-wide basis.

?*Pronesopupa* sp. Tutuila. Cryptogenic. The single specimen found of this unidentified species is tiny: height 0.7 mm, width 0.6 mm. It is probably not fully grown. It has an appearance similar to species of *Pronesopupa*, particularly in the absence of teeth in the aperture and in the presence of fine periostracal flanges that form low spines around the periphery of the shell (see Pilsbry, 1920–21). It does not match any Samoan material in the Bishop Museum collections and may be an undescribed species. It does not match any of the species listed for the Samoan archipelago (Cowie, 1998c) and is therefore to be considered a new record. It may be endemic to Tutuila or to the Samoan archipelago; or it may be naturally widespread in the Pacific; or it may be a recent alien introduction to Tutuila.

Status. Only a single dead shell was found (98.5). This extremely small species may have been overlooked by previous collectors/surveys, and may be under-represented in the 1998 survey. Its apparent extreme rarity may simply reflect this. In the absence of knowledge of its status as endemic, indigenous or alien its conservation status cannot be assessed.

PARTULIDAE

Eua zebrina. Tutuila, Ofu. Endemic. This species was previously only recorded from Tutuila (Cowie, 1998c). It is extremely variable in shell color and pattern, ranging from white, through yellow-brown to dark purple-brown, with or without a zebra-like pattern of flecks and lines. It is a tree snail, as are other partulids, but it has been reported on the

ground where it has been shown to feed on other snails (Cooke, 1928), although these are probably only a very minor part of its diet.

Status. Solem (1975) considered this species "widely distributed and abundant", as is also attested by the enormous numbers of shells that make up the chandeliers in the lobby of the Rainmaker Hotel in Pago Pago (Cowie, 1993). By 1992 it appeared much less common, found alive at only two of the nine sites surveyed on Tutuila (Miller, 1993). It was listed as a candidate for endangered/threatened status by the USFWS in 1994, and as threatened by the IUCN in 1996. During the 1998 survey the site on "Tiatauala ridge" (in fact Sauma ridge) at which the 1992 survey team recorded nine individuals (Miller, 1993) was revisited, but despite intensive searching no individuals were seen there, suggesting it may have disappeared from this location. However, it was found alive at 24 stations of the 87 that constituted the quantitative survey on Tutuila. A total of 684 live individuals was recorded at these 24 stations. The three stations with the greatest abundance were all at Amalau (98.79, 98.80, 98.178) where 97, 181, and 201 live *E. zebrina* were recorded, respectively. Station 98.79 was also one of only three locations at which *Trochomorpha apia* was recorded (see below), and station 98.80 was also the station with the highest numbers of another partulid, *Samoana conica* (below). Seven other stations had significant numbers of live *E. zebrina*: 98.48 (27), 98.62 (10), 98.63 (16), 98.64 (40), 98.157 (16), 98.169 (23), 98.170 (33). The remainder each had fewer than ten. In addition, 21 live individuals were recorded at opportunistic stations (98.18, 98.19, 98.166, 98.167, 98.174, 98.175, 98.176, 98.177, 98.179, 98.182) and 397 were recorded elsewhere along the trails (Appendix 7). Thus, during the entire survey, 1,102 live *Eua zebrina* were recorded. Empty shells but no live snails were found at quantitative stations 98.6, 98.26, 98.30, 98.31, 98.154, 98.160, at opportunistic stations 98.168 and 98.180, and alongside trails (Appendix 7).

These stations at which *E. zebrina* was recorded on Tutuila are scattered through the Park, although, with the exceptions of the spectacular Amalau populations, there is a clear tendency for them to be concentrated in the central area: Toa ridge, Faiga ridge, and eastwards to the Vatia powerline trail and as far as Tofu stream, and along Alava ridge from the radio towers to the top of the Vatia powerline trail and a little beyond. Elsewhere in the Park, there appears to be a slight tendency for them to be found towards the lower ends of the ridge trails. This distribution pattern (see Appendix 9), with a concentration in the central area, is very similar to the patterns exhibited by the two other partulids found on Tutuila, *Samoana conica* and *S. abbreviata* (below).

Two of the three stations at Amalau are within an inholding in the National Park. By October 1998, ongoing development in this inholding had resulted in clearing of vegetation right up to the edge of the area populated by *Eua zebrina* (and *Samoana conica*) at station 98.80, and a track had been cleared alongside the site down to the ocean. At that time the populations seemed not to have been impacted. For comparison with the numbers of *E. zebrina* collected in March 1998 (181), in October a similar timed collection was made and 164 individuals were found. The development had apparently not yet impacted the population. The area from these two stations and along transect 14A (Figure 2) supports the highest concentration of *Eua zebrina* recorded during the survey.

The finding of *Eua zebrina* on Ofu is extraordinary. New island records for partulids in the Pacific are extremely rare. The snails were relatively abundant at this site (98.143): 88 recorded during the timed collecting period.

Eua zebrina is therefore perhaps less close to extinction than previously thought (Miller, 1993). However, it has clearly suffered serious decline, even since 1975 (Solem, 1975), and all partulids are vulnerable because of their slow reproduction and growth (Cowie, 1992). The populations in the National Park are important for the future of this species, because the Park is a protected area that will not be subject to severe development, logging, and other potentail threats. As there are as yet no predatory snails (*Euglandina rosea*) on Ofu, this population, although outside the Park boundary, is especially significant.

Samoana abbreviata. Tutuila. Endemic. This species seems closely related to *Samoana conica* (below), but its shells are dextral (coil to the right) whereas those of *S. conica* are sinistral (coil to the left). Its shell is generally yellowish-green in color.

Status. This species had not been seen alive since 1940 (Solem, 1975; Miller, 1993), until the 1998 survey. Both Solem (1975) and Miller (1993) tentatively considered it extinct. It was listed as a candidate for endangered/threatened status by the USFWS in 1994, although considered probably extinct. IUCN in 1996 listed it as "data deficient", that is, probably threatened but IUCN had insufficient information to make that determination. In the 1998 survey, a total of eight live individuals was seen at seven of the quantitative survey stations. Three of these stations were on Alava/Maugaloa ridge (98.18, 98.55, 98.64); one each were at mid-elevations on Faiga ridge (98.44) and along the Vatia powerline trail (98.56); and two were on Toa ridge (98.165, 98.169). Single empty shells were collected at each of two additional stations on Maugaloa ridge (98.20, 98.23), and one each on Pagatatua ridge (98.49), Levaga ridge (98.160) and Polauta ridge (98.182). Five additional live individuals were seen at five points along the Alava/Maugaloa ridge trail; one was seen high on Toa ridge; and one was seen on Polauta ridge (Appendix 7). Thus, a total of 15 live individuals was seen. This is the least common of the three Tutuila partulids. Its distribution strongly mimics those of *Eua zebrina* (above) and *Samoana conica* (below), with a concentration in the central area from Toa ridge to the Vatia powerline trail and along Alava/Maugaloa ridge in this area (Appendix 9). Finding *Samoana abbreviata* alive is of major significance, but it is clearly surviving in extremely low numbers and is certainly highly endangered.

Samoana conica. Tutuila. Endemic. This species seems closely related to *Samoana abbreviata* (above), but its shells are sinistral (coil to the left) whereas those of *S. abbreviata* are dextral (coil to the right). Its shell is generally more yellowish, less rounded, and more conical than that of *S. abbreviata*.

Status. Solem (1975) considered this species "widely distributed and abundant". By 1992 it appeared much less common, found alive at only one of the nine sites surveyed on Tutuila (Miller, 1993). It was listed as a candidate for endangered/threatened status by the USFWS in 1994, and as threatened by the IUCN in 1996. During the 1998 survey the site on "Tiatauala ridge" (in fact Sauma ridge) at which the 1992 survey team recorded it (Miller, 1993) was revisited. In 1992 four individuals were seen at this site, but despite

intensive searching none was seen there during the 1998 survey. However, it was found alive at 20 of the 87 quantitative stations sampled during the survey, empty shells being found at an additional five. A total of 142 live snails was found at these 20 stations. The highest numbers (31) were at station 98.80, also the station at which another partulid, *Eua zebrina*, was most abundant (above). Significant numbers were found at five other stations: 98.42 (26), 98.55 (11), 98.64 (11), 98.161 (19), 98.170 (12). The remainder each had fewer than ten. In addition, three live individuals were recorded at a single opportunistic sampling station (98.18) and 143 were recorded elsewhere along the trails (Appendix 7). Thus, during the entire survey, 288 live *Samoana conica* were recorded. Empty shells but no live snails were found at quantitative stations 98.21, 98.49, 98.50, at opportunistic station 98.70, and alongside trails (Appendix 7).

As for *Eua zebrina* and *Samoana abbreviata* (above), and with the exception of the Amalau population, the distribution of *S. conica* centers around Toa ridge, Faiga ridge, and eastwards to the Vatia powerline trail and a little beyond, and along Alava ridge from the radio towers to the top of the Vatia powerline trail. There is a hint that on the ridges west of Toa ridge it tends to be found at higher elevations than *Eua zebrina*.

As indicated above under *Eua zebrina*, the station with the highest numbers (98.80) is likely to be seriously impacted by development. For comparison with the numbers found there in March 1998 (31) a similar timed collection was made in October 1998 and 35 *S. conica* were found. As for *Eua zebrina*, the development had apparently not yet impacted the population.

Although *S. conica* is considerably more widespread and abundant than *S. abbreviata*, it is not as widespread as *Eua zebrina* and is much less abundant than this species And given that the station at which it was most abundant is likely to be subject to future development (see *Eua zebrina*, above, and *Trochomorpha apia*, below), *Samoana conica* should be considered endangered.

Samoana thurstoni. Ofu. Endemic. This species may also be closely related to *S. abbreviata* and *S. conica*, its shells being of a greenish-yellowish color. It is dextral.

Status This species was described in 1930 by Cooke & Crampton (1930) from material collected in 1926 from "near the summit" of Ofu. Only eight specimens were collected. [Although Cooke & Crampton (1930) mentioned only three being presented to the Bishop Museum, in fact there are eight in the collections, apparently all collected on the same expedition: collection catalog numbers BPBM 83119 (2 snails), 83121 (2 snails), 10853 (1 snail), 189706 (3 snails).] The statement of Cooke & Crampton (1930) regarding the collection locality is misleading. In fact the collection catalog entry in the Bishop Museum reads: "1/4 mi. W. of Tumu, main ridge, 1 mi. from shore, el. 900' ". The species was considered extremely rare at the time. However, in 1975 it was reported as "in fair numbers at 1,300–1,400' [396–427 m] elevation" (Solem, 1975), and two lots of specimens were collected and deposited in the Field Museum of Natural History in Chicago, one containing a single specimen (FMNH 181114), the other containing nine (FMNH 181109) (John Slapcinsky, personal communication). The survey in 1992 (Miller, 1993) recorded a single specimen that was not collected, at the summit of Ofu. The species was listed as a candidate for endangered/threatened status by the USFWS in 1994, and as threatened by the IUCN in 1996. During the 1998 survey, it was found again (not

collected) at the summit of Ofu (98.140) close to the flagging tape marking the 1992 locality (four individuals: two adults, one subadult, one juvenile) as well as at a site below the summit (98.142; eight individuals: four adults, one subadult, three juveniles). This site is at an elevation of 322 m, lower than the 1975 site. At neither of these sites could the snails be considered as occurring "in fair numbers". Only 31 individuals have thus ever been collected or reported by western science, 12 of them recorded during the 1998 survey. Clearly, additional survey work is needed to ascertain the species' true distribution, but it seems likely that nowhere will it be found in large numbers and those populations that exist are problably all confined to the undisturbed parts of the upper slopes of Ofu, entirely outside the Park boundaries. This restricted distribution, outside of any preserved area, combined with the species' low population densities, suggest that it is under significant potential threat and should be considered seriously endangered.

SUBULINIDAE

Subulinid species are extremely difficult to distinguish from each other. Representative specimens from the 1998 survey were sent to a subulinid expert and the identifications reported here are based on comparison of all material with the material identified by the expert. Nevertheless, because of the extreme difficulty, there may be some misidentifications.

Allopeas clavulinum. Tutuila, Ta'ū, Ofu. Alien. The only published information regarding this species in the Samoan archipelago (Cowie, 1998c) is based on a tentative record from Tutuila in 1992. However, it is quite likely that it has been in the Samoan archipelago much longer than this and that it is widespread. It probably originated in tropical East Africa (Kerney *et al.*, 1979). Its current and potential impacts are unkown, but it contributes to the overall subulinid biomass and therefore to the overall impacts of subulinids (see *Subulina octona*, below).

Status. This species is the third most common subulinid in the National Park (following *Subulina octona* and *Paropeas achatinaceum*; see below). In 1998 it was recorded on Tutuila at 20 stations (alive at 9) of the 87 surveyed quantitatively, on Ta'ū at 11 (alive at six) of the 41 stations surveyed quantitatively and at two stations sampled opportunistically (alive at one), and on Ofu at three of the 17 stations surveyed quantitatively (none alive).

Lamellaxis micra. Ofu. Alien. This is the first record of this species in the Samoan archipelago. It occurs naturally in northern South America and the Caribbean region (Baker, 1945; Pilsbry, 1906–07; Pilsbry, 1946). Elsewhere in the Pacific it has been recorded in New Caledonia (Solem, 1964; Gargominy *et al.*, 1996). Cowie (1997) indicated that it might be present in the Hawaiian islands, recorded under the name *Opeas beckianum* (Pfeiffer, 1846) [= *Beckianum beckianum*], but this now seems unlikely because the Hawaiian specimens referred to are indeed *Beckianum beckianum* and not *Lamellaxis micra* (R.H. Cowie, personal observations). However, given the difficulty of indentifying subulinids, *L. micra* may well be present in other parts of the region. Its

current and potential impacts are unkown, but it contributes to the overall subulinid biomass and therefore to the overall impacts of subulinids (see *Subulina octona*, below).

Status. At present this species is only known from two stations on Ofu. Because of the difficulty of distinguishing subulinid species, earlier records of other species may refer to this species and it may in fact be more widespread.

Opeas hannense. Ofu. Alien. This species has been recorded previously from 'Upolu, and tentatively from Tutuila (Cowie, 1998c). Although described from West Africa, it is probably a central American species, but has been distributed widely by humans, frequently being reported as the junior synonyms *Opeas goodallii* (Miller, 1822) and *Opeas pumilum* (Pfeiffer, 1840) (Cowie, 1997, 1998c; Kerney *et al.*, 1979; Pilsbry, 1906–07). Its current and potential impacts are unkown, but it contributes to the overall subulinid biomass and therefore to the overall impacts of subulinids (see *Subulina octona*, below).

Status. This species was recorded from only two stations on Ofu. Because of the difficulty of distinguishing subulinid species, earlier records of other species may correctly refer to this species and it may in fact be more widespread.

Paropeas achatinaceum. Tutuila, Ta'ū, Ofu. Alien. This is a widespread species, especially in the tropical Indo-Pacific, probably distributed in large part through human activities. It probably originates from south-east Asia (Pilsbry, 1906–07), where it is widely distributed (Naggs, 1994). The only published information regarding this species in the Samoan archipelago (Cowie, 1998c) is based on a tentative record from Tutuila and tentative records of the junior synonym *javanica* Reeve, 1849 from Savai'i and 'Upolu (in 1992–94). It has undoubtedly been in the Samoan islands much longer than this. As for *Subulina octona* (below), it seems highly likely that it has had an impact on native species abundance, through competition, although there is no direct evidence of this. It and the other subulinids are also probably a major food resource for carnivorous snails (see below) that may impact native species through predation.

Status. This species is one of two very widespread and abundant subulinids in the National Park (the other being *Subulina octona*; see below). In 1998 it was recorded on Tutuila at 69 stations (alive at 49) of the 87 surveyed quantitatively and at one station sampled opportunistically, on Ta'ū at 23 (alive at 12) of the 41 stations surveyed quantitatively and at two stations sampled opportunistically, and on Ofu at 10 of the 17 stations surveyed quantitatively (alive at two). Although as widespread as *Subulina octona* (below), it was rarely as abundant.

Subulina octona. Tutuila, Ta'ū, Ofu. Alien. This species has been previously recorded from Tutuila and all three Manu'a islands, and tentatively from 'Upolu (Cowie, 1988c). It is probably on all islands and has probably been there for a considerable time. It is one of the commonest snails distributed around the world by human activities. It probably is native to the neotropics (Kerney *et al.*, 1979). It seems highly likely that it has had an impact on native species abundance, through competition, although there is no direct evidence of this. It and the other subulinids are also probably a major food resource for carnivorous snails (see below) that may impact native species through predation.

Status. This species is extremely widespread and abundant in the National Park, being by far the commonest ground-dwelling snail. In 1998 it was recorded on Tutuila at 69 stations (alive at 39) of the 87 surveyed quantitatively, on Ta'ū at 23 (alive at 12) of the 41 stations surveyed quantitatively and at one station sampled opportunistically, and on Ofu at 14 of the 17 stations surveyed quantitatively (alive at nine). Although equally widespread as *Paropeas achatinaceum* (above), it was usually more abundant, frequently by far the dominant litter-dwelling species at a station in terms of numbers of individuals.

ACHATINIDAE

Achatina fulica. Tutuila, Ta'ū. Alien. This species, the giant African snail, has been introduced widely in the humid tropics, frequently becoming an agricultural and garden pest. Its pest status has led to the introduction of predatory snails in attempts at biological control, with resultant serious impacts on native snail faunas (see Partulidae, Spiraxidae, Streptaxidae).

Status. The giant African snail was first reported in American Samoa in 1977, subsequently spreading rapidly throughout Tutuila (Cowie, 1998c). Eldredge (1988) reported it from the Manu'a islands (not specifying which) but considered it to have been eradicated. However, in 1992 it was recorded on Ta'ū, as well as on Tutuila, although not on Ofu or Olosega (Cowie, 1993; Miller, 1993). It has also reached 'Upolu (Cowie, 1998c). During the 1998 survey it was recorded at 26 stations on Tutuila, as well as incidentally at 12 locations along the trails (Appendix 8). These records were scattered throughout the Park, although notably it was not recorded on Faiga ridge. On Ta'ū, it was recorded at two stations (98.94, 98.96), with incidental observations at a further two locations (Appendix 8), all being along the Lata mountain trail. It was not recorded on Ofu. *A. fulica* does not occur in American Samoa in the immense population densities pictured by Mead (1961). Anecdotal information suggests that perhaps in the past on Tutuila it did occur in greater abundance than it now does; it may be declining there, as it has in the Hawaiian islands (Cowie, 1992). On Ta'ū it may be in the initial phase of colonization and its distribution and abundance may well increase.

SPIRAXIDAE

Euglandina rosea. Tutuila. Alien. This carnivorous snail has been widely introduced, from its native Florida, throughout the tropics and subtropics, putatively for control of *Achatina fulica*. However, there is no good evidence that it has provided effective control of *A. fulica*, despite some claims to the contrary, but there is ample evidence of its devastating effects on native land snail faunas, especially in the Pacific (Civeyrel & Simberloff, 1996; Cowie, 1992, 1996b, 1997; Hadfield, 1986; Hadfield *et al.*, 1993; Murray *et al.*, 1989). It will even go under water to attack freshwater snails (Kinzie, 1992). It has probably been a major contributor to the decline of native snail populations on Tutuila and perhaps Ta'ū (Cowie, 1993; Eldredge, 1988; Miller, 1993; Miller *et al.*, 1993; Trail, 1993). Its continued presence poses an ongoing threat to the native snail species in the Park, especially the slow-growing and slow-reproducing partulids.

Status. This species was first introduced to American Samoa, to Tutuila, in 1980. By 1992 it had also been introduced to Ta'ū (Miller, 1993; Smith, 1992). It appears not to have reached Ofu/Olosega. During the 1998 survey it was recorded only on Tutuila, at 44 of the 87 quantitatively sampled stations, at seven opportunistically sampled stations, and incidentally at nine additional locations along the trails (Appendix 8). These records were from scattered locations throughout the Park. Clearly, *Euglandina rosea* is more or less ubiquitous; whether its numbers are increasing or decreasing is unknown; but the abundant alien subulinids (above) in particular probably provide a significant food resource for it. Although it was not recorded on Ta'ū during the 1998 survey, it is probably still present there, and its populations on Ta'ū may increase to an extent that they could become a threat to the native species of that island.

STREPTAXIDAE

Gonaxis kibweziensis. Tutuila. Alien. Various species of *Gonaxis*, all African in origin, have been introduced to Pacific islands in attempts to control *Achatina fulica* (Eldredge, 1988; Hopper & Smith, 1992; Cowie, 1998a). As yet, only one of these species, introduced in 1977 to Tutuila, has been recorded from the Samoan archipelago (Cowie, 1998c). Its impacts on native species are unknown.

Status. This species was recorded at two out of nine stations on Tutuila in 1992 (Miller, 1993). As yet, it is only known to occur on Tutuila. In the 1998 survey it was found at 25 of the 87 stations sampled quantitatively on Tutuila, alive at 11 of them, and at six opportunistic stations, as well as being seen incidentally along the trails at five locations (Appendix 8). Although it seems widespread, it is notable that it was not recorded on Sauma/Tiatauala, Olo, and Maatulua ridges. Whether it is still increasing and spreading is unknown.

Gulella bicolor. Ofu, Alien. This small carnivorous species is now widely distributed in the tropics, probably largely as a result of human activities, though whether deliberately or accidentally introduced is unknown. Its geographic origin in either Africa or Asia is not clear (Cowie, 1997). It is generally found at lower elevations, often associated with habitats disturbed by human activities. Its impacts are unknown.

Status. This species was not reported by either Solem (1975) or Miller (1993). Prior to the 1998 survey it had been recorded tentatively from Tutuila but not from any other islands (Cowie, 1998c). This is the first record from Ofu. Although during the 1998 survey it was only found on Ofu, in very small numbers at three stations (98.138, 98.144, 98.147) and only as dead shells, it may be more widespread. Whether it is increasing or declining is unknown.

Streptostele musaecola. Tutuila, Ta'ū, Ofu. Alien. This small carnivorous species was first recorded from American Samoa, on Tutuila only, in 1975 (Solem, 1975). Whether it was accidentally or deliberately introduced is unknown. It appears to be tropical African in origin (Pilsbry, 1919). Its impact on native snail populations is also unknown, although both Solem (1975) and Miller (1993) conjectured that it may have been implicated in the extinction of native species. This is the first report of its occurrence on Ta'ū and Ofu.

Status. In 1975 this species was reported as "abundant at one station" on Tutuila (Solem, 1975). It was not recorded in 1992 (Miller, 1993). It was extremely rare during the 1998 survey, being found in very low numbers at only one station on Tutuila (98.32), one on Ta'ū (98.98), and three on Ofu (98.137, 98.138, 98.140). It seems that it may remain rare and have little impact on native species.

RHYTIDIDAE

Ouagapia gradata. Tutuila, Ta'ū, Ofu. Indigenous. This small, poorly-known species is carnivorous. It has also been recorded from Savai'i and 'Upolu, and from Tonga (Kondo, 1943).

Status. Collections in the Bishop Museum suggest that this species was once relatively widespread (especially on Ta'ū) although perhaps not notably abundant. In 1975 it was found at at least one station on Ta'ū and at least five on Tutuila (total at least six stations out of 20 sampled); it was not considered threatened (Solem, 1975). It was not recorded in the 1992 survey (Miller, 1993). Now it appears to be extremely rare, at least in the National Park, being found during the 1998 survey at only one station on Tutuila (98.78, one live specimen), two stations on Ta'ū (98.91, one live specimen; 98.94, one dead shell), and one station on Ofu that was outside the National Park (98.143, one empty shell). It appears to be seriously endangered.

SUCCINEIDAE

Succinea manuana. Ta'ū, Ofu. Endemic. It is possible that this species and *Succinea modesta* (below) are in fact the same species, but resolution of this question requires additional taxonomic research.

Status. In 1975 this species was considered common on Ta'ū and in no danger of extinction (Solem, 1975). By 1992 it was considered uncommon (Miller, 1993), although it was found at one of only two areas surveyed on Ta'ū and at one of three areas on Ofu. In 1998 it was found at eight stations on Ta'ū (alive at only two: 98.103, 98.133). On Ofu it was found at nine stations, two of which (98.137, 98. 143) were outside the Park boundary. No live specimens were found on Ofu but this may reflect the fact that at four of the nine stations at which this arboreal species was found vegetation was not sampled. This species is fairly widespread, but only found alive in small numbers. It may be declining and warrants careful monitoring.

Succinea modesta. Tutuila. Indigenous. This species is also recorded from 'Upolu and Tonga (Cowie, 1998c). It is possible that this species and *Succinea manuana* (above) are in fact the same species, but resolution of this question requires additional taxonomic research.

Status. In 1975 this species was considered widely distributed on Tutuila, tolerant of "moderate degrees of habitat disturbance", "common in ecotonal areas to forest and plantation patches", and "in no immediate danger of extinction" (Solem, 1975). In 1992 it was found alive at only one of the nine locations surveyed on Tutuila (Miller, 1993). During the 1998 survey it was recorded at 13 stations, alive at seven, scattered

sporadically throughout the Park. However, it was never found in large numbers and may be declining. It warrants careful monitoring.

HELICARIONIDAE

Diastole schmeltziana. Tutuila, Ta'ū, Ofu. Endemic. This species appears distinct from the probably undescribed *Diastole* n. sp. (below) in having a paler shell and a more blotchy pattern of white body coloration showing through the shell. There appear not to be intermediates between the two taxa. Published records indicate *D. schmeltziana* on Tutuila and Ofu, and on 'Upolu, but it may occur on all the main islands of the archipelago (Baker, 1938; Cowie, 1998c). The "variety" *usurpata*, which may not deserve separation as a distinct taxon (but see *Diastole* n. sp., below), is recorded from Ta'ū and Savai'i, in addition to Ofu and 'Upolu (Cowie, 1998c). This is the first formal record from Ta'ū of the nominal subspecies *D. schmeltziana sensu stricto*. It was listed as a candidate for endangered/threatened status by the USFWS in 1994. A small number of dead specimens could not be referred to this species or *Diastole* n. sp. (below); they undoubtedly belong to one or other of them and are listed in the appendices as *Diastole* sp.

Status. In 1975 this species was considered common and widespread on Tutuila, and perhaps becoming more so, although it was not reported from Ta'ū or Ofu. In 1992 it was found at two out of nine sites on Tutuila and one of three on Ofu, but was not recorded from Ta'ū. During the 1998 survey it was found to be widespread in the Tutuila unit of the National Park (31 stations, all but one being part of the quantitative survey), generally not at low elevations, only at high elevations on Ta'ū (above 400 m, five quantitatively sampled stations), and on Ofu on and near the top of Tumu mountain (three quantitatively sampled stations). It does not seem to be declining and appears not to be threatened.

Diastole n. sp. Ta'ū, Ofu. Endemic. This species appears distinct from *Diastole schmeltziana* in having a darker shell and a finer, less blotchy pattern of white body coloration showing through the shell. There appear not to be intermediates between the two taxa. It is possible that this un-named species should be referred to *usurpata* (see above), which would then warrant raising *usurpata* to full species status; but this would require additional taxonomic research beyond the present scope. It is more likely an undescribed species and is tentatively listed here as such. In the 1998 survey it was found with *D. schmeltziana* at three stations on Ta'ū (98.87, 98.88, 98.89) and two on Ofu (98.139, 98.140) as well as alone at an additional station on Ta'ū (98.125). It was less widespread than *D. schmeltziana*, and at most stations at which they co-occurred it was less abundant. A small number of dead specimens could not be referred to this species or to *Diastole schmeltziana*, above; they undoubtedly belong to one or other of them and are listed in the appendices as *Diastole* sp.

Status. This species appears restricted to a small number of locations, and is assumed at this stage to be endemic to the Manu'a group. As Solem (1975) suggested regarding the apparent decline of *Diastole matafaoi* Baker, 1938 on Tutuila, *Diastole* n. sp. may be being replaced by *D. schmeltziana*, but this is sheer conjecture (in both cases). Nevertheless, this species deserves attention.

Liardetia samoensis. Tutuila, Ta'ū, Ofu. Indigenous. This species is widespread in the Pacific and elsewhere. It was reported specifically from Tutuila and Ofu by Solem (1975) and is also known from 'Upolu. This is its first formal record from Ta'ū. Additional survey work may locate it on all the main islands of the Samoan archipelago.

Status. This species was once abundant in American Samoa but appeared already to have declined by 1975 (Solem, 1975) and now seems rare, at least in the National Park. It was found at six stations on Tutuila (98.31, 98.57, 98.66, 98.152, 98.157, 98.169), three on Ta'ū (98.101, 98.107, 98.130), and two on Ofu (98.148, 98.150), all part of the quantitative surveys. Its status elsewhere in its range must be evaluated before it should be considered under threat on a world-wide basis.

Ovachlamys fulgens. Tutuila. Alien. This is the first record of this species in the Samoan archipelago. However, its identification remains slightly uncertain (David Robinson, personal communication). Described from the Ryukyu islands of Japan, it has been transported around the world, frequently via the orchid trade, from Japan, through Thailand, and to Costa Rica, where it is now a horticultural pest (David Robinson, personal communication). It is increasingly regularly intercepted entering the U.S., mostly from Costa Rica, on a wide variety of plants (such as *Croton*, *Codiaeum*, *Dracaena*, etc.). It has recently been found in the Hawaiian islands (Cowie, 1999).

Status. At present this alien species seems widely, although patchily, established in the National Park on Tutuila (11 quantitatively sampled stations). Whether it will increase in abundance is unknown, but it will likely expand its distribution, probably to include the other islands of the archipelago, especially if inadvertently assisted by human activities. Its impacts or likely impacts are unknown.

ARIOPHANTIDAE

Parmarion martensi. Tutuila. Alien. This south-east Asian species is a semi-slug, that is, it has a shell but cannot withdraw its body fully into it, and the mantle covers much of the shell. It has been recorded from Tutuila (Cowie, 1998c) and was collected in 1992 on 'Upolu (R.H. Cowie, personal observations). However, all identifications of this species have so far been tentative. Nevertheless, assuming correct identification, it appears to be a widely introduced species, having been reported from Cambodia, Taiwan, Singapore and the Hawaiian islands (Cowie, 1998d).

Status. This species was first reported from Tutuila by Miller (1993). During the 1998 survey it was only found on Tutuila, at nine stations, six quantitative, three opportunistic. These stations were patchily distributed through the Park. Whether it will increase in abundance is unknown, but it will likely expand its distribution to become more widespread in the Park, and probably to include the other islands of the archipelago, especially if inadvertently assisted by human activities. Its impacts or likely impacts are unknown.

ZONITIDAE

Trochomorpha apia. Tutuila. Endemic. This species is also recorded from 'Upolu and Savai'i. It is found on tree trunks and logs.

Status. In the 1975 survey it was found at "several stations" and was not thought to be under any threat (Solem, 1975). In 1992 empty shells were seen at two out of nine sites on Tutuila but no live individuals were found. It was listed as a candidate for endangered/ threatened status by the USFWS in 1994, and as threatened by the IUCN in 1996. It was recorded at only one station during the 1998 survey (98.79), although live snails appeared common there, and incidentally at two additional locations close together in the area to the east of the Vatia powerline trail at about 295 m elevation (Appendix 8). Station 98.79 is within an inholding in the National Park. Ongoing development in this inholding might impact the snails, if not by clearing of vegetation, then as a result of increased disturbance, increased spread of alien plant species into the area, increased human activity nearby, leading to increased numbers of rats that would predate the snails. Although this species' status on 'Upolu and Savai'i is not known, the likelihood is that it has become rare there also. In American Samoa the species seems extremely rare and is probably highly endangered.

BRADYBAENIDAE

Bradybaena similaris. Ofu. Alien. This eastern Asian species is now widespread in tropical and subtropical regions, including many Pacific islands, as a result of dispersal by humans. It is often associated with human disturbance, although it is also found in undisturbed habitats, as was the single sample taken during this survey (98.141). It has also been recorded from Tutuila and 'Upolu and tentatively from Ta'ū and 'Aunu'u (Cowie, 1998c).

Status. This alien species was not found in the National Park, the only station at which it was found during the survey being outside the Park at the summit of Tumu mountain on Ofu. It does not appear to be common generally, although it may be more common in highly disturbed habitats, which were not the focus of the 1998 survey. Whether it is increasing or declining is unknown.

4.2. Patterns of distribution

There are few clear patterns of distribution (see maps in Appendix 9) that might suggest especially diverse areas within the Park, which might warrant more careful management. However, some comments are possible, as follows.

4.2.1. Tutuila

In addition to the spectacular and isolated populations at Amalau of *Eua zebrina* in particular but also of *Samoana conica*, there is a clear tendency for the three partulid species (*E. zebrina*, *S. abbreviata*, *S. conica*) to be concentrated in the central area: Toa ridge, Faiga ridge, and eastwards to the Vatia powerline trail and as far as Tofu stream

(approx. half way from the Vatia powerline trail to Tiatauala ridge), and along Alava ridge from the radio towers to the top of the Vatia powerline trail and a little beyond.

Orobophana musiva was found almost exclusively on transects 4 (Plantation ridge) and 5 (Muliulu point trail), and at Amalau, i.e., excluding the central area, notably transects 6–9 and 10A (Leemo ridge to Toa ridge). Somewhat similar distributions, also excluding this central area, were exhibited by *Assiminea parvula* and *Omphalotropis* sp. A. In contrast, the distribution of *Elasmias* sp. seemed to center on this area.

Among the alien predatory snails *Gonaxis kibweziensis* exhibited a somewhat disjunct distribution focused on transects 1, 2, 4 and 5 and on the central area of greatest partulid abundance.

A number of species were widely distributed, occurring at large numbers of stations but with no obvious pattern: *Pleuropoma fulgora*, *P. beryllina*, *Achatina fulica*, *Euglandina rosea*, *Allopeas clavulinum*, *Paropeas achatinaceum*, *Subulina octona*, *Diastole schmeltziana*. Other species, occurring at far fewer stations, were sporadically distributed but also with no obvious pattern: *Laevicaulis alte*, *Vaginulus plebeius*, *Succinea modesta*, *Liardetia samoensis*, *Ovachlamys fulgens*, *Parmarion martensi*. A few species were so rare, occurring at very few stations, that it is not possible to detect any patterns in their distributions: *Ostodes adjunctus*, *?Pronesopupa* sp., *Streptostele musaecola*, *Ouagapia gradata*, *Trochomorpha apia* (although this last species was found only at Amalau and in the central area of partulid abundance).

Three species (*Pythia scarabaeus*, *Melampus fasciatus*, *Melampus castaneus*) are upper shoreline or immediate coastal forest species. These habitats were not surveyed extensively and the poor representation of these species in the survey is probably not indicative of their distributions and abundances.

Thus, there is a hint of greater diversity in the central area, notably in the area that constitutes the focus of the partulid diversity, and perhaps a slightly reduced diversity in the area from transect 6 (Leemo ridge) to 10A (Toa ridge).

4.2.2. Ta'ū

Because the survey encompassed much higher elevations on Ta'ū than it did on either Tutuila or Ofu, more pronounced elevational patterns of distribution of some species might be expected to have been recorded. In fact there do seem to be such patterns. *Pleuropoma* n. sp. was strictly confined to the highest elevation stations. *Pleuropoma beryllina* (with the exception of one low elevation station) was found only above about 300 m elevation, and *Diastole schmeltziana* only above about 400 m (and not on the Laufuti stream survey route). *Diastole* n. sp. exhibited a similar pattern to its congener but did not reach the top of Lata mountain and was found at one station on the Laufuti stream survey route). It is interesting but unexplained that *Pleuropoma beryllina* and *Diastole*

schmeltziana exhibited these high elevation patterns as they were apparently not so constrained on Tutuila.

Contrasting with these species with higher elevation distributions are a number of species that are widely distributed but that do not reach the higher elevations: *Orobophana musiva*, *Allopeas clavulinum*, *Subulina octona*. One species, *Succinea manuana*, was less frequently encountered but was only found at lower elevations.

Achatina fulica was only found near Fitiuta, up the Lata mountain trail as far as Luatele. This may be a reflection of its spread from a center of human population (the village of Fitiuta).

Two species were widely distributed but with no apparent elevational pattern: *Pleuropoma fulgora* (not found along the east coast) and *Paropeas achatinaceum*.

The unidentified Veronicellidae (slugs) were too sporadically distributed to detect any pattern. And a number of species were too rare: *Assiminea parvula*, *Omphalotropis* sp. B, *Elasmias* sp., *Streptostele musaecola*, *Ouagapia gradata*, *Liardetia samoensis*.

The upper shoreline species (*Melampus castaneus*, *Melampus fasciatus*, *Tralia costata*, *Truncatella guerinii*) were again not focused upon and the survey results probably do not reflect their real distributions. However, immediate coastal forest was surveyed in more detail than on Tutuila and *Pythia scarabaeus* was found at most stations located in this habitat (along the east and south coasts) and is undoubtedly widely distributed around the island.

4.2.3. Ofu

The survey on Ofu was not as extensive as those on Tutuila and Ta'ū because the Park on Ofu encompasses relatively little terrestrial habitat. However, in addition to sampling within the Park, a single series of stations was sampled outside the Park and included the highest point on the island, Tumu mountain. The purpose of this was to place the Park on Ofu in context in terms of the land snail fauna of the island. The few distributional patterns that were detected are only tentative because of the limited sampling.

Four species were only found at high elevations, all outside the Park: *Samoana thurstoni*, *Diastole* n. sp., *D. schmeltziana*, *Bradybaena similaris*. Three species were only found at low elevations: *Lamellaxis micra*, *Gulella bicolor*, *Succinea manuana*. A number of species were widespread but with no clear pattern: *Pleuropoma fulgora*, *Orobophana musiva*, *Paropeas achatinaceum* (not along the south shore), *Subulina octona*. One species, *Streptostele musaecola*, was less common and more sporadically distributed, but also with no clear pattern. The following species were confined to coastal or upper shore habitats, as elsewhere: *Truncatella guerinii*, *Melampus castaneus*, *Melampus fasciatus*, *Pythia scarabaeus*, *Tralia costata*. Other species were too rare to detect any pattern:

Omphalotropis sp., *Elasmias* sp., *Liardetia samoensis*, *Lamellidea pusilla*, *Ouagapia gradata*, *Eua zebrina*, *Opeas hannense*, *Pupisoma orcula*.

4.3. Overall changes in conservation status

It is difficult to draw rigorous comparisons with the 1975 and 1992 surveys, as they investigated different areas and made no quantitative evaluation of abundance. Solem (1975) made no clear distinction between abundant (which may be very localized) and common (which may mean widespread but not necessarily occurring in very large numbers locally). The definition of rarity is difficult as it combines both of these concepts (Cameron, 1998). Similarly, earlier surveys that resulted in large amounts of collected material (mostly now held in the Bishop Museum) have never been reported on or analyzed and so do not allow easy comparison of distribution and abundance patterns. Efforts to address this, initially by databasing all the information from these collections, are currently in progress (with National Science Foundation funding).

Despite these problems, it is still possible to develop a sense of changes, at least in abundance, as indicated under the individual species accounts (above, section 4.1). From these accounts, it appears that the majority of native species for which an assessment is possible are declining (14 species). Some of these (e.g., *Eua zebrina*) appear not to be as threatened as suggested by the previous reports (Solem, 1975, Miller, 1993), but this does not imply that their populations are increasing, simply that the 1998 survey was more thorough and investigated different areas. Others may be stable or even increasing (e.g., *Diastole schmeltziana*), while for others there is no obvious trend (e.g., *Omphalotropis* sp. A, *Elasmias* sp., *Samoana thurstoni*). One species remains widely abundant (*Pleuropoma beryllina*). One species, previously thought to be extinct (*Samoana abbreviata*) obviously declined dramatically a long time ago. However, it is still surviving, although in very small numbers; again, this does not imply that its populations are increasing and that it is not seriously threatened.

5. DISCUSSION

5.1. The fauna

The 1998 survey recorded 18 of the 42 native land snail species previously known from American Samoa, plus the two species of *Omphalotropis* that could not be definitively identified but which are also native. Within the Park boundaries the survey found 16 (plus the unidentified *Omphalotropis* sp. A) of the 29 native species known from Tutuila (59 % of the Tutuila snail fauna), six of the 12 known from Ta'ū (50 %), and five of the ten known from Ofu (50 %). Additional native species were recorded outside the Park on Ofu.

The survey also recorded 13 of the 18 alien species previously recorded from the Samoan archipelago, and three of the six previously known cryptogenic species. Two of the 13

aliens, although previously recorded from the archipelago, had not been recorded from American Samoa (the slugs *Laevicaulis alte* and *Vaginulus plebeius*). Two alien species previously not recorded from the archipelago were found (*Lamellaxis micra*, *Ovachlamys fulgens*). Some of these alien species (e.g., *Subulina octona*) were found in huge abundance. This large contribution of alien species to the overall fauna (see Table 1), combined especially on Tutuila with the frequent occurrence of a new introduction (*Ovachlamys fulgens*), and the continuing spread of other alien species to new islands within the archipelago, clearly indicates that although the National Park is protected from urban and agricultural development, logging, and other threats, and therefore constitutes a potential refuge for native and endemic species, its land snail fauna, as with most land snail faunas of tropical islands, is being homogenized (Cowie, 1998a, b).

The survey found six species previously unrecorded in the Samoan archipelago. One, *Tralia costata*, is an uncommon but widespread species in the Pacific. Its absence from previous records reflects this rarity and the probability that previous collectors did not search intensively in its usual supralittoral habitat. *Ovachlamys fulgens* is a recent introduction of a species that will probably become more widespread in the Pacific, possibly through association with the horticultural trade, which bears heavy responsibility for the inadvertent transport of many snail species around the world (e.g., Cowie, 1999). Another introduced species, *Lamellaxis micra*, may have been in the archipelago for some time without being recognized. The undescribed species of *Pleuropoma* and *Diastole*, which are assumed to be endemic, are counted among these new records as neither has been mentioned in the literature. And the unidentified species designated "?*Pronesopupa*" is likewise counted as a new record.

In addition to new records for the archipelago, there are a 22 new island records (Table 2). Most notable is the finding of *Eua zebrina* on Ofu. The new records of *Truncatella guerinii* from Ta'ū and Ofu (a new record for American Samoa as a whole) no doubt simply reflect previous lack of intensive collecting in supralittoral habitats. *Pupisoma orcula* is a widespread but uncommon species in the Pacific; the new record from Ofu (the only island on which it was found in 1998) probably simply reflects this rarity. The new island records of subulinids, all of which are widespread alien species, reflect lack of former interest in these taxa among researchers. Careful review of the Bishop Museum collections may well reveal that these species had been collected from these islands previously, but simply never reported. Such review is beyond the scope of this report. The two streptaxids now reported from Manu'a, also alien species, have been in the Samoan islands for unknown lengths of time. Being small, they are probably easily transported accidentally. Both are widespread in the Pacific (Solem, 1989) and may be expanding their ranges. The new record of *Diastole schmeltziana* from Ta'ū is surprising, because it was common, but may reflect lack of previous collecting at higher elevations. Solem (1975) considered it to be expanding its range and abundance on Tutuila, and if this were also the case on Ta'ū it absence from previous collections might reflect its earlier rarity. The new record of *Liardetia samoensis* form Ta'ū may simply reflect this species' rarity and small size. The new records of *Melampus castaneus* on Tutuila, Ta'ū, and Ofu (new for American Samoa as a whole) probably reflect taxonomic uncertainty. Thus, these new

island records are a mixture of new records of species that were probably always present but were simply not recorded and records that genuinely reflect expanding distributions, especially of alien species.

Notable absences from the survey collections were the Endodontidae and Charopidae. Seven species (including one species known only from Swains) are known from American Samoa (Cowie, 1998c). Solem (1975) considered them all extinct. Miller (1993) reported a single dead shell, but no live snails, collected in 1992. Reasons for the apparently almost complete extinction of these species are not known, although Solem (1976) attributed it primarily to predation on their eggs by introduced ants. Another absence of note is *Gastrocopta pediculus* (Pupillidae), a widespread and probably artificially introduced species through much of the Pacific. It was extremely abundant where it occurred (Pilsbry, 1916–18), including at low elevation on Ofu (Kirch, 1993), but was not recorded by Solem (1975) or Miller (1993). It therefore appears to have declined dramatically. The reason(s) for this are unknown.

The evaluations of whether species are under threat or not must be treated with some caution. The 1998 survey focused on the National Park; some species considered rare in the Park may be more common outside its boundaries, and species considered abundant in the Park, may be scarce elsewhere. Previous survey work (e.g., Miller, 1993; Solem, 1975) covered different areas, making comparison with those surveys difficult. A rigorous evaluation of each species' status would require extensive and intensive survey work outside the Park. Such a major survey effort is unlikely to be undertaken in the foreseeable future. Nevertheless the Park does include a significant amount of the most pristine native forest remaining (Whistler, 1992, 1994) and therefore would be expected to include some of the best places for native snails to still be found and where they would remain at relatively high abundances. If an endemic species appears rare and threatened within the Park, it is likely that it is equally rare and threatened in areas of relatively pristine forest located outside the Park, and that it is even more rare and threatened (or absent) in less pristine areas. A cautious evaluation of its global status, on the basis of its status in the Park, seems reasonable and in fact is the only possible evaluation given the state of present knowledge and the likelihood that adequate survey work outside the Park will not be undertaken in the forseeable future. Regarding apparent changes in abundance and distribution (as opposed to a static evaluation based solely on data from the 1998 survey), in most cases we do not have more than a highly subjective assessment, although this assessment does suggest that the majority of native species are declining (see section 4.3.). Arguably, all native/endemic species are under threat as the fauna is increasingly dominated by alien species. Monitoring is essential.

5.2. Threats

5.2.1. Predators

The impacts on the native snail species of the various alien predators that have been introduced to the islands of the Pacific probably depend to a large extent on the life-

histories of the native species. The slow-growing and slow-reproducing Partulidae (and Achatinellinae in the Hawaiian islands) seem to be particularly susceptible. This may be because a major predation episode can reduce a population dramatically, and because of their life-history characteristics the population is then unable to build up again quickly. Thus, when faced with continuous predation pressure of this kind, populations decline rapidly, perhaps to the point of extinction. Populations of more rapidly-growing and reproducing species can rebound much more quickly and the predators may have little effect on populations of these species; other factors may limit their populations. This may be part of the explanation for the apparent drastic decline in numbers of partulids (and certain other species), while other species (e.g., *Pleuropoma beryllina*, *Diastole schmeltziana*) appear to be thriving.

5.2.1.1. *Predatory snails*

Considerable evidence strongly implicates the carnivorous predatory snail *Euglandina rosea* (above) in the decline of native snails wherever it has been introduced (Civeyrel & Simberloff, 1996; Griffiths *et al.*, 1993). Direct evidence that *E. rosea* has caused decline comes especially from Moorea (French Polynesia), where the disappearance of native partulids mirrored the spread of *E. rosea* across the island (Murray *et al.*, 1989). In the Hawaiian islands *E. rosea* seems almost certainly to have had a major influence on populations of achatinelline tree snails (Hadfield, 1986; Hadfield *et al.*, 1993), and it probably has also been causal in the decline of partulids on Guam (Hopper & Smith, 1992). There is no adequate evidence anywhere that *E. rosea* has caused declines of the giant African snail, *Achatina fulica* (above), for which it was introduced as a putative biological control agent (Cowie, 1992). Indeed, decline of *A. fulica* has in some instances occurred in the absence of predatory snails. *Euglandina rosea* is widespread on Tutuila, including within the National Park (see above). It has arguably had a severe impact on populations of native snails, perhaps the partulid tree snails in particular (Miller, 1993); *E. rosea* has been recorded in trees (e.g., station/sample 98.154.1). It is also reported from Ta'ū, where its impacts are unknown. As yet it has not been found on Ofu or Olosega. *Samoana thurstoni* seems particularly vulnerable should *E. rosea* be introduced to Ofu.

Other predatory snails, notably species of *Gonaxis*, also widely introduced in the Pacific in attempts to control *Achatina fulica*, have also been implicated, though less strongly, in contributing to the decline of native snail species in the region. As yet in the Samoan archipelago, *Gonaxis kibweziensis* has only been recorded from Tutuila. However, other streptaxids have been recorded: *Streptostele musaecola* from Tutuila, Ta'ū and Ofu, and *Gulella bicolor* from Ofu. The potential impacts of these two species on the native fauna are unknown; both are much smaller than *Euglandina rosea* or *Gonaxis kibweziensis*. However, Solem (1975) speculated that *S. musaecola* might have a role in the further decline of native species; and Miller (1993) considered that it "undoubtedly had a negative impact", although with no direct evidence to support his contention.

5.2.1.2. *Rodents*

Three species of rats are present in the Samoan islands: *Rattus exulans*, the Polynesian rat, probably introduced by early Polynesian colonizers, and *Rattus rattus* and *Rattus norvegicus*, both introduced subsequent to western contact. All three have been implicated in the decline of native snail populations in the Hawaiian islands (Hadfield *et al.*, 1993), and are probably of significance in Samoa. Frequent evidence of predation by rats (characteristic damage to shells found on the ground) was encountered during the 1998 survey, as it was in 1992 (Miller, 1993). Rats will eat even a large *Achatina fulica*; characteristically damaged specimens were encountered at least as large as 7 cm in shell height. Rats will also climb trees to feed on tree snails.

Some shells were also found that had damage that was similar to that due to rats, but the damaged shells were of small snail species (notably helicinids) and the characteristic hole in the shell was much smaller. Perhaps other rodents (mice) are present in the Park and are feeding on snails; the Park's General Management Plan (Ainu'u, 1997) reports the presence of the house mouse, *Mus musculus*.

5.2.1.3. *Flatworm*

The introduced predatory flatworm *Playtdemus manokwari* is now considered one of the most significant threats to the remaining land snail fauna of Guam (Hopper & Smith, 1992). It has also been reported in the Hawaiian islands (Eldredge, 1994). It has recently been introduced to Samoa (Western) in unsanctioned efforts to control *Achatina fulica* (Anonymous, 1999a), but as yet has not been introduced to American Samoa.

5.2.2. Competitors

It has been noted above that the land snail fauna of the Park, particularly the ground-dwelling fauna, is becoming dominated by introduced species, notably subulinids. Whether these species are competing with native species for food resources, space, or anything else is unknown. However, given the large numbers of these introduced species it seems not unreasonable to consider competition to be possible, and this may be one reason for the decline of the native litter-dwelling species especially. In addition, these large numbers of alien species probably provide a ready food resource sustaining the predators discussed above.

5.2.3. Invasive plants and habitat modification

Invasive nonindigenous plants can seriously modify native habitat and render it unsuitable for native snail species (e.g., Hadfield, 1986). Insufficient is known of the ecology, especially the feeding habits, of the native snails to permit accurate prediction of their ability to modify their behavior and survive adequately on nonindigenous vegetation. However, the fact that few native snails are found in disturbed habitats outside the Park (R.H. Cowie, personal observations), and indeed that this is the case more generally

throughout the Pacific, suggests that they have little ability to modify their behavior and are specialized to survive only on the native plants with which they have evolved.

The serious invasion of the habitat alongside the Vatia powerline trail in the Tutuila unit of the Park is illustrative. At the top of the trail, on Maugaloa ridge, there is a thick concentration of invasive nonindigenous ginger. Associated with this is a high abundance of alien veronicellid slugs, and few other snails. The forest immediately alongside the Vatia powerline trail is some of the most disturbed in the Park, with the understory particularly dominated by nonindigenous plants (see also Whistler, 1994, p. 3). To find native snails it is necessary to move off the trail and out of this corridor of alien plants. Clearly this habitat modification has resulted directly from the installation of the cables, with propagules of alien species likely being transported accidentally on human clothing (footware especially) and on equipment. A corridor (Andrews, 1990; Zink *et al.*, 1995) has been created along which alien species can travel and from which they can disperse farther into the native forest, extending the disturbance.

Feral pigs constitute a significant problem in the Park because of the damage they cause to vegetation, particularly through their rooting and wallowing activities. Whether pigs have a significant effect on the land snail fauna, other than directly where they damage the vegetation and substrate, is not known. However, the Park has initiated a major effort to control pigs by snaring and by restricting their movements with fences. Two main fences have been installed in the Tutuila unit of the Park: one from the main ridge to Agapie cove, and one from the ridge to Siufaga point. Fences are proposed for portions of Olo ridge. Installation of fences involves disturbance of habitat, probably in much the same way as did the installation of the Vatia powerline. Native vegetation is cleared or damaged along the fence corridor and nonindigenous plants are accidentally introduced.

As the Park becomes increasingly accessible (below), the problems associated with invasive plants and the consequent habitat modification will increase.

Park authorities recognize that the Park is established within a human social and cultural context, and permit continued traditional use of the Park. However, there remains the possibility that further agricultural encroachment into the Park may take place, replacing native forest with plantation. Such habitat will not support the majority of native snail species.

5.2.4. Development

The installation of the Vatia powerline is a clear example of how development can negatively modify native habitat. There are a number of other developments, planned or under consideration by the Park, that may have similar effects. These include a visitor center near the radio station on Alava ridge, and the development of the trail along Alava/Maugaloa ridge, permiting more ready access for public hiking. Clearly construction of buildings and other facilities will destroy the habitat of the site itself. However, the construction process involves increased trafffic, both vehicular and on foot, that will

facilitate increased erosion and increased introduction of alien plants. During the course of the 1998 survey, construction equipment used the unpaved road access to the radio tower on Alava ridge in order to replace the cable car cable. There was clear evidence of increased erosion dowslope of the road resulting from destruction and modification of the road's drainage systems by heavy vehicles. Not only will construction itself result in habitat destruction or modification, but any increase in public access that the development encourages will lead to habitat modification, in particular resulting from the increased introduction of alien plants.

Of particular concern is the proposed private development within the Amalau inholding of the Park. As has been indicated above, this proposed development is adjacent to the most abundant populations of two species of partulid tree snails, *Eua zebrina* and *Samoana conica*, as well as one of only two known extant populations of *Trochomorpha apia*. From a conservation perspective this location is one of the most significant in or near the Park. Development around this location might have significant impacts on the snails. Even if the vegetation supporting the actual snail populations is not cleared, increased encroachment of disturbed habitat, increased spread of alien plant species into the area, increased human activity nearby, facilitating not only further spread of alien plants but also leading to increased numbers of rats that would predate the snails, are all potential effects of development of this area.

6. RECOMMENDATIONS

6.1. Partulids

The finding of *Eua zebrina* on Ofu (a new island record) and of *Samoana thurstoni* at a location other than its previously only known locations are of major significance. *E. zebrina* was previously only known from Tutuila, but there its populations are threatened by the predatory snail *Euglandina rosea*, and, perhaps, by the potential impacts of development. Ofu does not yet have *E. rosea*. Hence the Ofu population of *E. zebrina* is of major conservation significance. *S. thurstoni* is endemic to Ofu and has only been reported from four localities, all near the top of Tumu mountain, and only in very low numbers (only 31 individuals ever recorded, including those seen during the 1998 survey). Additional survey work on Ofu is therefore needed to determine the distributions of these species. The known populations should be protected. At present none of these populations of either species are within the National Park. The feasibility of including these areas in the Park should be investigated.

On Tutuila all three partulid species (*Eua zebrina*, *Samoana abbreviata*, *S. conica*) were found to have similar distributions, with most records centered around Toa ridge, Faiga ridge, and eastwards to the Vatia powerline trail and a little beyond, and along Alava ridge from the radio towers to the top of the Vatia powerline trail. *Eua zebrina* and *Samoana conica* also had important populations at Amalau. All these populations are subject to present and/or future disruption from development (see below, section 6.4). If possible,

this development should be curtailed completely or at least limited, in order to prevent or reduce impacts on the snail populations, which should be carefully monitored.

Samoana abbreviata had for many years been thought to have gone extinct. That it is not extinct, although surviving only in very low numbers, is an important finding. That the center of its distribution is clearly on and around the central ridges of the Tutuila unit of the Park, further stresses the need to take great care when decisions are made on if and how this area should be developed.

The importance of this central area and the Amalau area in the Tutuila unit of the Park are further stressed because they are the only two localities at which *Trochomorpha apia* was found.

6.2. Protection from predators

Probably rats and *Euglandina rosea* are the most serious predators of native snails. It is highly unlikely that it would be possible to eradicate either from the Park. However, it may be possible to establish small managed areas within the Park from which these predators are eradicated. Experiments in Moorea (French Polynesia) to exclude *E. rosea* have demostrated the theoretical feasibility of doing this (Clarke & Pearce-Kelly, 1997). In the Hawaiian islands, rat numbers have been reduced locally by baiting (Hadfield *et al.*, 1993), and baits to kill *E. rosea* are being developed (Hadfield, 1998).

Introduction of *Euglandina rosea* to American Samoa was against the express written protests of widely respected land snail experts and others. As yet, *E. rosea* has only been recorded on Tutuila and Ta'ū. Strenuous efforts should be made to prevent it being introduced to Ofu and Olosega. It would likely be introduced if *Achatina fulica* were to be introduced to these islands. So the most important action will be to prevent the introduction of *A. fulica*. This requires public education, including radio and TV announcements, newspaper articles, posters. The current experience on 'Upolu, where *A. fulica* has been causing increasing problems, as well as past experience on Tutuila, could be used to highlight the damage *A. fulica* can cause. In the event that *A. fulica* reaches Ofu and Olosega, introduction of *E. rosea*, or any other predatory snail species, as a putative biological control agent should not be countenanced.

Just as *E. rosea* should not be introduced to Ofu/Olosega, neither should the predatory flatworm *Platydemus manokwari* be released anywhere in AmericanSamoa. Reports (e.g., Anonymous, 1999a) that it can control *A. fulica* in Samoa (Western) are unproven, though it has been reported as providing good control elsewhere (Anonymous, 1999b). The individuals promoting its use as a biological control agent appear either to consider it harmless to native snail species (incorrect) or simply do not care about native species (Muniappan, 1983, 1987, 1990; Muniappan *et al.*, 1986). It has the potential to very seriously impact native snail faunas, as has been suggested on Guam (Hopper & Smith, 1992). The Park should be alert to this threat.

The National Park should be at the forefront of actions in support of these preventive endeavors by providing information and offering expert opinion.

6.3. Prevention of habitat modification

The areas within the National Park represent a significant portion of the remaining native Samoan forest (Whistler, 1992, 1994). As such they constitute important habitat for many of the native and endemic land snails of American Samoa. Protection of this habitat is therefore an important part of any effort to prevent the demise of this unique snail fauna. The Park's General Management Plan (Ainu'u *et al.*, 1997) explicitly recognizes the significance of this habitat. Many factors can lead to detrimental modification of this native habitat; two in particular seem the most significant or potentially significant.

Traditional use of the Park will continue, but Park authorities must be alert to increased use, especially agricultural (plantation) encroachment farther into the Park.

Feral pigs constitute one of the most serious agents in the modification of native habitats. Park authorities recognize this and are implementing a program of pig management. The goal should be pig eradication. Installation of fencing to control pigs must be undertaken with due regard for the ease with which this activity could facilitate the introduction of alien plant species along the fence corridor.

In addition, generally increased activity and possible development in the Park will inevitably lead to an increasing chance of introduction and establishment of alien plants. Every effort should be made to prevent this, probably in large part through education (see below, section 6.8).

6.4. Development

Development is intimately tied to increased habitat modification. While the Park is mandated to develop access to and interpretation of its resources, it should do this in ways that least impact those resources.

Increasing access to the Park along the unpaved road from Fagasa pass to the Alava mountain radio tower, especially vehicular access, should be discouraged. It will result in erosion and increased spread of alien plants. This trail should be developed as a hiking trail only.

The trail from the radio tower along Alava and down to Vatia (the Vatia powerline trail, or "Historic Vatia trail") is to be developed for public access. This trail cuts directly through the apparent center of distribution of all three Tutuila species of Partulidae—*Eua zebrina*, *Samoana conica*, *Samoana abbreviata* (see maps, Appendix 9, and above section 6.1). However, although little increase in foot traffic is predicted, these partulid populations should be carefully monitored both before and after trail development.

On Tutuila, the only other trail under consideration is the trail from the north-west end of Vatia across the saddle on Polauta ridge to the strand on the western side of the ridge. No quantitative sampling was done in this area, but *Eua zebrina* was recorded on the western side of the saddle and could be impacted by trail development. Both *E. zebrina* and, particularly notably, *Samoana abbreviata* were found high on Polauta ridge, but this area is difficult to access and development of the trail is unlikely to impact these populations.

Development of the inholding at Amalau is continuing rapidly. Between the March and October 1998 field trips, extensive land clearing had taken place, right up to the edge of the area harboring the most abundant yet apparently isolated population of *Samoana conica* recorded during the1998 survey (station 98.80) and the larger and apparently more extensive area occupied by the most abundant *Eua zebrina* population recorded (station 98.80 and northwestwards in the forest between the coast and the road) (see maps, Appendix 9). Less than 100 m distant from this development is one of only two areas (three stations) harboring *Trochomorpha apia*. The *S. conica* population is under severe threat; the *T. apia* population probably also is; and the *E. zebrina* population is likely to be significantly impacted. Therefore, this development must be halted or limited as much as possible.

On Ta'ū, a trail up Laufuti stream is under consideration, as is a forest canopy trail. Most species of snails on Ta'ū are widely distributed and this amount of development, although having a local impact, may not jeopardize the snail fauna overall. Nevertheless, all the potential impacts of development mentioned above, notably habitat modification, should be minimized.

6.5. Monitoring

The major component of the 1998 survey involved quantitative sampling. Following the same procedures in future will permit quantitative comparison with the 1998 baseline of data on distributions and abundances. Continued monitoring should permit reliable evaluation of trends in the snail populations, which could then form the basis of management decisions for the Park that incorporate these important invertebrates.

For monitoring to be implemented it must be simple so that relatively untrained personnel can undertake it, and quick so that it takes up the minimum of staff time, given the Park's limited resources. The field guide to the land snails of the Samoan archipelago (Cowie, in preparation) will be an important resource permitting relatively easy species identifications. It is suggested that a team of four spend one week annually recording certain selected snail species at a small number of selected stations. The combination of selected species and stations could then be used as an indicator of the status of snails in the Park. Both arboreal and ground-dwelling species should be considered, as should native and non-native species; an increase in non-native species may be as significant as a decrease in native species.

More detailed monitoring every five years, perhaps involving all species and a larger suite of sampling stations, would provide information for those species not included in the annual monitoring and permit a more accurate overall evaluation of trends.

Casual recording of the status of known populations should be undertaken at any available intermittant opportunity, in case development changes are rapid (e.g., Amalau, above).

Populations of partulids and of *Trochomorpha apia* should be monitored more comprehensively as they may be more susceptible to threats, especially development.

6.6. GIS and databases

The data from all surveys including the 1998 survey should be databased and incorporated into the Park's GIS program. Evaluation of patterns, including patterns of changing distribution and abundance, could then be monitored efficiently. Overlaying patterns of distribution and abundance of other plant and animal species would also permit identification of parts of the Park that are particularly pristine and/or rich in biodiversity, allowing them to be targeted for special attention.

6.7. Endangered species listing

Formerly, eight Samoan snail species were considered by the USFWS as candidates for listing as endangered or threatened species (USFWS, 1994). These were: *Ostodes strigatus* (not recorded in the Park), *Eua zebrina*, *Samoana abbreviata*, *Samoana conica*, *Samoana thurstoni* (not recorded in the Park), *Diastole matafaoi* (not recorded in the Park), *Diastole schmeltziana*, *Trochomorpha apia* (Table 3). Only *Eua zebrina* and *Ostodes strigatus* were listed as category 1 candidates; the remainder were listed as category 2 candidates.

Category 1 candidate species were species for which the USFWS had on file substantial information on biological vulnerability and threats to support proposals to list the species as endangered or threatened. Category 2 candidate species were species for which information in the possession of the USFWS indicated that proposing to list the species as endangered or threatened was possibly appropriate, but for which conclusive data were not available. USFWS procedures have now changed: category 1 candidates are simply termed "candidate species"; category 2 candidates are now termed "species of concern". Proposed species are candidate species for which the USFWS has processed the necessary paperwork to generate a listing proposal. The purpose of a listing proposal is to make the information available for public scrutiny, which is part of the process leading to formal listing as endangered or threatened. Only once a species is formally listed as endangered or threatened does it have any legal status in terms of being protected under the Endangered Species Act. Candidate and proposed species do not have any legal status in this regard, but the USFWS believes that they should be listed as endangered or threatened and has enough information to support this belief. Species of concern also have no legal status under the Endangered Species Act. However, the USFWS maintains lists of species of

concern, because, even though there is not enough information to support a listing proposal, expert opinion suggests that the species are under threat. The USFWS uses the lists of species of concern as guidance in planning future activities, such as new survey work. Species of concern may be considered for listing in the future.
With these changes in USFWS procedures and the disappearance of the candidate category 2, only *Eua zebrina* and *Ostodes strigatus* remain as candidates, the other species are "species of concern".

The IUCN listed a number of Samoan species in its *1996 Red List* (IUCN, 1996) under the following categories: threatened—*Thaumatodon histricelloides* (Western Samoa only), *Eua zebrina*, *Samoana conica*, *Samoana thurstoni*, *Trochomorpha apia*; extinct—*Diastole matafaoi* (not recorded in the Park); data deficient—*Samoana abbreviata*.

All these species should be re-evaluated by both USFWS and IUCN on the basis of this report; tentative evaluations are summarized in Table 3. All other endemic Samoan species recorded herein should also be evaluated and efforts should be made to formally list those that are deemed threatened or endangered (see also Table 2). The Park should support these efforts.

6.8. Education

In general, increasing public awareness of the unique biota of the Samoan archipelago and the major role the National Park has to play in its conservation is of great significance.

More specifically, and given that there will be some level of development and probably increased public use of the Park, users of the Park should be clearly informed of the importance of not disturbing plants and animals and of not introducing alien plants (on footwear and clothing). The issue of native snail declines, and the role of partulid snails in Samoan folk crafts should be incorporated into interpretive programming.

Table 3. Listing of endemic and possibly endemic Samoan species by USFWS and IUCN and current tentative evaluations of their conservation status based on the 1998 survey.

Former USFWS categories, from USFWS (1994), are C1—Candidate category 1, C2—Candidate category 2, C2*—Candidate category 2 but possibly extinct. IUCN categories are from the *1996 IUCN Red List of Threatened Animals* (IUCN, 1996).

Family and Species	USFWS (formerly)	USFWS (current)	IUCN	Present evaluation
HELICINIDAE				
Pleuropoma n. sp.	not listed	not listed	not listed	possibly endangered
POTERIIDAE				
Ostodes adjunctus (Mousson, 1869)	not listed	not listed	not listed	endangered
Ostodes strigatus (Gould, 1847)[1]	C1	candidate	not listed	-
ASSIMINEIDAE				
Omphalotropis sp. A	not listed	not listed	not listed	possibly endangered
Omphalotropis sp. B	not listed	not listed	not listed	possibly endangered
Omphalotropis sp.	not listed	not listed	not listed	possibly endangered
PARTULIDAE				
Eua zebrina (Gould, 1847)	C1	candidate	threatened	possibly endangered
Samoana abbreviata (Mousson, 1869)	C2*	species of concern	data deficient	endangered
Samoana conica (Gould, 1847)	C2	species of concern	threatened	endangered
Samoana thurstoni (Cooke & Crampton, 1930)	C2	species of concern	threatened	endangered
ENDODONTIDAE				
Thaumatodon hystricelloides (Mousson, 1865)[1]	not listed	not listed	threatened	-
SUCCINEIDAE				
Succinea manuana Gould, 1846	not listed	not listed	not listed	possibly endangered
HELICARIONIDAE				
Diastole matafaoi Baker, 1938[1]	C2	species of concern	extinct	-
Diastole schmeltziana (Mousson, 1865)	C2	species of concern	not listed	not endangered
Diastole n. sp.	not listed	not listed	not listed	possibly endangered
ZONITIDAE				
Trochomorpha apia (Hombron & Jacquinot, 1852)	C2	species of concern	threatened	endangered

[1] Not known to have ever ocurred within the area of the Park, nor recorded during the 1998 survey, so conservation status not evaluated.

7. ACKNOWLEDGEMENTS

We thank Chris Stein (formerly Superintendant, National Park of American Samoa) for intitiating and supporting this project and for participating in some of the field work. For assistance in the field we especially thank Mino Fialua, as well as Reynold Belford, Peter Craig, Anthony Crook, Ben Eiben, Ioane Ioane, Vai Misaalefua, Heidi Sherman, Siaifoi Faaumu, Don Vargo, Rory West, and Rory West, Jr. For assistance with identification of specimens we thank Fred Naggs (subulinids), Prof. José Willibaldo Thomé (veronicellids), David Robinson (*Ovachlamys fulgens*), and David Britton (helicinids). For loan of type specimens from the collections of the National Museum of Natural History (Smithsonian Institution) we thank Bob Hershler and Cheryl Bright. John Slapcinsky provided information from the collections in the Field Museum, Chicago. Peter Craig offered insight and guidance as the report was being written. We also thank Ray Tulafono (Director, American Samoa Department of Marine and Wildlife Resources) for his support.

This is contribution No. 1999.001 of Bishop Museum's Pacific Biological Survey.

8. LITERATURE CITED

Abbott, R.T. 1958. The gastropod genus *Assiminea* in the Philippines. *Proceedings of the Academy of Natural Sciences of Philadelphia* 110: 213–78, pls. 15–25.

Abbott, R.T. 1989. *Compendium of landshells*. American Malacologists, Inc., Melbourne, Florida. viii + 240 p.

Ainu'u, L.V., Barbano, G., Cook, R.P., Fake, T., Lane-Kamahele, M., Nakamura, J., Nakata, L. & Stein, C. 1997. *General management plan/environmental impact statement. National Park of American Samoa*. United States Department of the Interior/National Park Service. xiv + 302 p.

Andrews, A. 1990. Fragmentation of habitat by roads and utility corridors: a review. *Australian Zoologist* 26: 130–141.

Anonymous 1999a. When a worm kills a snail . . .. *SAPA Newsletter* 3(2/99): 7.

Anonymous 1999b. Giant African snail. *Plant Protection Service, Secretariat of the Pacific Community. Pest Advisory Leaflet No. 6*, 3 p.

Baker, H.B. 1938. Zonitid snails from Pacific islands—part 1. 1. Southern genera of Microcystinae. *Bernice P. Bishop Museum Bulletin* 158: 1–102, pls. 1–20.

Baker, H.B. 1945. Some American Achatinidae. *The Nautilus* 58(3): 84–92.

Cameron, R.A.D. 1998. Dilemmas of rarity: biogeographical insights and conservation priorities for land Mollusca. *Journal of Conchology Special Publication* 2: 51–60.

Carlton, J.T. 1996. Biological invasions and cryptogenic species. *Ecology* 77(6): 1653–1655.

Cernohorsky, W.O. 1972. *Marine shells of the Pacific. Volume II*. Pacific Publications, Sydney. 411 p.

Cernohorsky, W.O. 1978. *Tropical Pacific marine shells*. Pacific Publications, Sydney. 352 p.

Civeyrel, L. & Simberloff, D. 1996. A tale of two snails: is the cure worse than the disease? *Biodiversity and Conservation* 5: 1231–1252.

Clarke, D. & Pearce-Kelly, P. 1997. *Partula* update. *Tentacle, the Newsletter of the IUCN/SSC Mollusc Specialist Group* 7: 20–21.

Cooke, C.M., Jr. 1928. Food habits of *Partula zebrina* Gould. *Bulletin of the Bernice P. Bishop Museum* 47: 5–12.

Cooke, C.M., Jr. & Crampton, H.E. 1930. New species of *Partula*. *Bernice P. Bishop Museum Occasional Papers* 9(11): 1–9.

Cooke, C.M., Jr. & Kondo, Y. [1961]. Revision of Tornatellinidae and Achatinellidae (Gastropoda, Pulmonata). *Bernice P. Bishop Museum Bulletin* 221 [1960], 303 p.

Cowie, R.H. 1992. Evolution and extinction of Partulidae, endemic Pacific island land snails. *Philosophical Transactions of the Royal Society of London Series B Biological Sciences* 335: 167–191.

Cowie, R.H. 1993. Why tree snails are becoming scarce in Samoa. *Hawaiian Shell News* 41(3): 1, 9.

Cowie, R.H. 1996a. Variation in species diversity and shell shape in Hawaiian land snails: in situ speciation and ecological relationships. *Evolution* 49(6)[1995]: 1191–1202.

Cowie, R.H. 1996b. Pacific island land snails: relationships, origins, and determinants of diversity. In: *The origin and evolution of Pacific island biotas, New Guinea to eastern Polynesia: patterns and processes* (Eds. Keast, A. & Miller, Scott E.), p. 347–372. SPB Academic Publishing, Amsterdam.

Cowie, R.H. 1997. Catalog and bibliography of the nonindigenous nonmarine snails and slugs of the Hawaiian islands. *Bishop Museum Occasional Papers* 50: 1–66.

Cowie, R.H. 1998a. Patterns of introduction of non-indigenous non-marine snails and slugs in the Hawaiian islands. *Biodiversity and Conservation* 7(3): 349–368.

Cowie, R.H. 1998b. Homogenization of Pacific island snails. *World Conservation; quarterly bulletin of IUCN-The World Conservation Union* 4/97–1/98: 18.

Cowie, R.H. 1998c. *Catalog of the non-marine snails and slugs of the Samoan islands. Bishop Museum Bulletin in Zoology 3*. Bishop Museum Press, Honolulu. viii + 122 p.

Cowie, R.H. 1998d. New records of nonindigenous land snails and slugs in the Hawaiian islands. *Bishop Museum Occasional Papers* 56: 60.

Cowie, R.H. 1999. New records of alien nonmarine mollusks in the Hawaiian islands. *Bishop Museum Occasional Papers* 59: 48–50.

Cowie, R.H. in press. Non-indigenous land and freshwater molluscs in the islands of the Pacific: conservation impacts and threats. South Pacific Regional Environment Program Technical Report.

Cowie, R.H. in preparation. *Samoan snails and slugs: a field identification guide*.

Cowie, R.H., Allison, A., Howarth, F.G., Samuelson, G.A. & Evenhuis, N.L. 1996. Impacts of construction of the Palau Compact Road: survey of the non-marine fauna of the island of Babeldaob. *Bishop Museum Report to Wil Chee Planning, Inc.*, Honolulu. 44 p.

Cowie, R.H., Nishida, G.M., Basset, Y. & Gon, S.M., III. 1995. Patterns of land snail distribution in a montane habitat on the island of Hawaii. *Malacologia* 36(1-2): 155–169.

Eldredge, L.G. 1988. Case studies of the impacts of introduced animal species on renewable resources in the U.S.-affiliated Pacific islands. *In*: Smith, B.D., ed., Topic reviews in insular resource development and management in the Pacific U.S.-affiliated islands. *University of Guam Marine Laboratory Technical Report* 88: 118–146.

Eldredge, L.G. 1994. Introductions and transfers of the triclad flatworm *Platydemus manokwari*. *Tentacle. The Newsletter of the IUCN/SSC Mollusc Specialist Group* 4: 8.

Emberton, K.C., Pearce, T.A. & Randalana, R. 1996. Quantitatively sampling land-snail species richness in Madagascan rainforests. *Malacologia* 38(1-2): 203–212.

Franc, A. [1957]. Mollusques terrestres et fluviatiles de l'archipel Néo-Calédonien. *Mémoires du Muséum National d'Histoire Naturelle. Nouvelle Série. Série A, Zoologie* 3[1956]: 1–200, pls. 1–24.

Gargominy, O., Bouchet, P., Pascal, M., Jaffré, T. & Tourneur, J.-C. 1996. Conséquences des introductions d'espèces animales et végétales sur la biodiversité en Nouvelle-Calédonie. *Revue d'Ecologie (Terre et Vie)* 51: 375–402.

Girardi, E.-L. 1978. The Samoan land snail genus *Ostodes* (Mollusca: Prosobranchia: Poteriidae). *The Veliger* 20(3): 191–250.

Gould, S.J. 1991. Unenchanted evening. *Natural History* 9/91: 4–14.

Gregory, H.E. 1927. Report of the Director for 1926. *Bernice P. Bishop Museum Bulletin* 41: 1–45.

Griffiths, O., Cook, A. & Wells, S.M. 1993. The diet of the introduced carnivorous snail *Euglandina rosea* in Mauritius and its implications for threatened island gastropod faunas. *Journal of Zoology* 229: 79–89.

Hadfield, M.G. 1986. Extinction in Hawaiian achatinelline snails. *Malacologia* 27(1): 67–81.

Hadfield, M.G. 1998. Hawaiian *Achatinella/Partulina* tree snail update. *Tentacle* 8: 15.

Hadfield, M.G., Miller, S.E. & Carwile, A.H. 1993. The decimation of endemic Hawai'ian [sic] tree snails by alien predators. *American Zoologist* 33: 610–622.

Hopper, D.R. & Smith, B.D. 1992. Status of tree snails (Gastropoda: Partulidae) on Guam, with a resurvey of sites studied by H.E. Crampton in 1920. *Pacific Science* 46(1): 77–85.

IUCN (International Union for the Conservation of Nature and Natural Resources). 1996. *1996 IUCN Red List of Threatened Animals*. IUCN, Gland, Switzerland. 70 + 368 + 10 p.

Johnson, M.S., Murray, J. & Clarke, B. 1993. The ecological genetics and adaptive radiation of *Partula* on Moorea. *Oxford Surveys in Evolutionary Biology* 9: 167–238.

Kay, E.A. 1979. *Hawaiian marine shells*. Bishop Museum Press, Honolulu. xviii + 653 p.

Kerney, M.P., Cameron, R.A.D. & Riley, G. 1979. *A field guide to the land snails of Britain and north-west Europe*. Collins, London. 288 p., 24 pls.

Kinzie, R.A., III. 1992. Predation by the introduced carnivorous snail *Euglandina rosea* (Ferussac) on endemic aquatic lymnaeid snails in Hawaii. *Biological Conservation* 60(3): 149–55.

Kirch, P.V. 1993. Non-marine molluscs from the To'aga site sediments and their implications for environmental change. *Contributions of the University of California Archaeological Research Facility, Berkeley* 51: 115–121.

Kondo, Y. 1943. Anatomical studies of three species of *Ouagapia* (Pulmonata, Agnatha, Paryphantidae). *Occasional Papers of the Bernice P. Bishop Museum* 17(19): 229–48.

Martins, A.M. de F. 1995. A new species of *Pythia* Röding, 1798 (Pulmonata, Ellobiidae), from New Ireland, Papua New Guinea. *Molluscan Research* 16: 59–67.

Mead, A.R. 1961. *The giant African snail: a problem in economic malacology.* University of Chicago Press, Chicago. xvii + 257 p., 8 pls.

Miller, S.E. 1993. Final report on surveys of the arboreal and terrestrial snail fauna of American Samoa. Unpublished report submitted to the United States Fish and Wildlife Service, Honolulu. 30 p.

Miller, S.E., Cowie, R.H., Smith, B.D. & Rojek, N. 1993. The decline of partulid snail populations in American Samoa. *Species* 20: 65.

Morton, J.E. 1955. The evolution of the Ellobiidae with a discussion on the origin of the Pulmonata. *Proceedings of the Zoological Society of London* 125: 127–68.

Mousson, A. 1869. Faune malacologique terrestre et fluviatile des îles Samoa, publiée d'après les envois de M. le Dr E. Graeffe. *Journal de Conchyliologie* 17(4): 323–90, pls. 14, 15.

Muniappan, R. 1983. Biological control of the giant African snail. *In*: *Programme, abstracts and congress information, Fifteenth Pacific Science Congress, vol. 1.* p. 172. Pacific Science Association, Dunedin.

Muniappan, R. 1987. Biological control of the giant African snail, *Achatina fulica* Bowdich, in the Maldives. *FAO Plant Protection Bulletin* 35(4): 127–133.

Muniappan, R. 1990. Use of the planarian, *Platydemus manokwari*, and other natural enemies to control the giant African snail. *In*: *The use of natural enemies to control agricultural pests.* p. 179–183. Food and Fertilizer Technology Center for the Asian and Pacific region, Taipei.

Muniappan, R., Duhamel, G., Santiago, R.M. & Acay, D.R. 1986. Giant African snail control in Bugsuk island, Philippines, by *Platydemus manokwari*. *Oléagineux* 41(4): 183–186.

Murray, J.J. 1989. Extinction by intent. *The Virginia Explorer* 5(12): 8–9.

Murray, J., Murray, E., Johnson, M.S. & Clarke, B. [1989]. The extinction of *Partula* on Moorea. *Pacific Science* 42(3–4) [1988]: 150–53.

Naggs, F. 1994. The reproductive anatomy of *Paropeas achatinaceum* and a new concept of *Paropeas* (Pulmonata: Achatinoidea: Subulinidae). *Journal of Molluscan Studies* 60(2): 175–91.

Pilsbry, H.A. 1906–07. *Manual of Conchology. Second series: Pulmonata. Vol. XVIII Achatinidae: Stenogyrinae and Coeliaxinae*. Academy of Natural Sciences, Philadelphia. xii + 357 p., 51 pls.

Pilsbry, H.A. 1916–18. *Manual of Conchology. Second series: Pulmonata. Vol. XXIV Pupillidae (Gastrocoptinae)*. Academy of Natural Sciences, Philadelphia. xii + 380 p., 49 pls.

Pilsbry, H.A. 1919. A review of the land mollusks of the Belgian Congo chiefly based on the collections of the American Museum Congo expedition, 1909–1915. *Bulletin of the American Museum of Natural History* 40(1): 1–370, pls. 1–23.

Pilsbry, H.A. 1920–21. *Manual of Conchology. Second series: Pulmonata. Vol. XXVI Pupillidae (Vertiginidae, Pupillinae)*. Academy of Natural Sciences, Philadelphia. iv + 254 p., 18 pls.

Pilsbry, H.A. 1946. Land Mollusca of North America (North of Mexico). Volume II. Part 1. *The Academy of Natural Sciences of Philadelphia Monographs* 3: frontispiece + vi + [ii] + 1–520.

Smith, C.W. 1992. Management of alien species in natural areas of Oceania. *Pacific Science* 46(3): 386–387.

Solem, A. 1964. New records of New Caledonian nonmarine mollusks and an analysis of the introduced mollusks. *Pacific Science* 18(2): 130–137.

[Solem, A.] 1975. Final report. Office of Endangered Species contract 14-16-0008-873. Unpublished report. 9 p.

Solem, A. 1976. *Endodontoid land snails from Pacific islands (Mollusca: Pulmonata: Sigmurethra). Part I. Family Endodontidae*. Field Museum of Natural History, Chicago. xii + 508 p.

Solem, A. 1983. *Endodontoid land snails from Pacific islands (Mollusca: Pulmonata: Sigmurethra). Part II. Families Punctidae and Charopidae. Zoogeography*. Field Museum of Natural History, Chicago. ix + 336 p.

Solem, A. [1989]. Non-camaenid land snails of the Kimberley and Northern Territory, Australia. I. Systematics, affinities and ranges. *Invertebrate Taxonomy* 2(4)[1988]: 455–604.

Springsteen, F.J. & Leobrera, F.M. 1986. *Shells of the Philippines*. Carfel Seashell Museum, Manila. 377 p.

Trail, P.W. 1993. Invaders are here. *American Samoa Department of Marine and Wildlife Resources Report* 42: 48–50.

USFWS (United States Department of the Interior Fish and Wildlife Service). 1994. Endangered and threatened wildlife and plants; animal candidate review for listing as endangered or threatened species. Federal Register 59(219): 58982–59028.

Wagner, A.J. 1905. Helicinenstudien. *Denkschrift der Kaiserlichen Akademie der Wissenschaften, Wien. Mathematisch-Naturwissenschaftliche Klasse* 77: 357–450, pls. 1–9.

Wagner, A.J. 1907–11. Die Familie der Helicinidae. *In*: Küster, H.C., ed., *Systematisches Conchylien-Cabinet von Martini und Chemnitz. Neu herausgegeben und vervollständigt*. Band 1. Abtheilung 18. Theil 1. Neue Folge. Bauer & Raspe, Nürnberg [= Nuremberg]. 391 p., 70 pls.

Whistler, W.A. 1992. Botanical inventory of the proposed Ta'u [sic] unit of the National Park of American Samoa. Cooperative National Park Resources Studies Unit, Hawaii, Technical Report 83, [ii] + 85 + [xiv] p.

Whistler, W.A. 1994. Botanical inventory of the proposed Tutuila and Ofu units of the National Park of American Samoa. Cooperative National Park Resources Studies Unit, Hawaii, Technical Report 87, [ii] + ii + 142 p.

Zink, T.A., Allen, M.F., Heindl-Tenhunen, B. & Allen, E.B. 1995. The effect of a disturbance corridor on an ecological reserve. *Restoration Ecology* 3(4): 304–310.

APPENDIX 1. TUTUILA: DETAILS OF SAMPLING STATIONS

Station numbers are field numbers of Robert H. Cowie. "98" indicates the year (1998). The second number is the sample station. Elevations are approximate—see text, section 3.1.1. Sample times (for quantitative samples only, not opportunistic samples) are the total number of person-minutes spent searching vegetation (v) and ground (g).

98.1. Sauma/Tiatauala ridge. 3 March 1998. Elevation 269 m. The site at which the 1992 survey found *Eua zebrina* and *Samoana conica*. 155 min (v), 5 min (g).

98.2. Sauma/Tiatauala ridge. 3 March 1998. Elevation 435 m. Top of ridge where trail intersects Maugaloa ridge trail. 105 min (v), 15 min (g).

98.3. Sauma/Tiatauala ridge. 3 March 1998. Elevation 383 m. 105 min (v), 15 min (g).

98.4. Sauma/Tiatauala ridge. 3 March 1998. Elevation 361 m. Opportunistic sample; not part of the quantitative survey.

98.5. Sauma/Tiatauala ridge. 3 March 1998. Elevation 310 m. 105 min (v), 15 min (g).

98.6. Sauma/Tiatauala ridge. 3 March 1998. Elevation 187 m. 105 min (v), 15 min (g).

98.7. Sauma/Tiatauala ridge. 3 March 1998. Elevation 131 m. 105 min (v), 15 min (g).

98.8. Lalofutu point trail. 4 March 1998. Elevation 1 m. Opportunistic sample; not part of the quantitative survey. Close to shore on boulders just at the edge of the terrestrial vegetation.

98.9. Lalofutu point trail. 4 March 1998. Elevation 3 m. 75 min (v), 15 min (g).

98.10. Lalofutu point trail. 4 March 1998. Elevation 57 m. 75 min (v), 15 min (g).

98.11. Lalofutu point trail. 4 March 1998. Elevation 127 m. 75 min (v), 15 min (g).

98.12. Lalofutu point trail. 4 March 1998. Elevation 170 m. Opportunistic sample; not part of the quantitative survey.

98.13. Lalofutu point trail. 4 March 1998. Elevation 207 m. 75 min (v), 15 min (g).

98.14. Lalofutu point trail. 4 March 1998. Elevation 247 m. 75 min (v), 15 min (g).

98.15. Lalofutu point trail. 4 March 1998. Elevation 268 m. Opportunistic sample; not part of the quantitative survey.

98.16. Lalofutu point trail. 4 March 1998. Elevation 320 m. 10 m elevation below road along main ridge. 75 min (v), 15 min (g).

98.17. Siufaga point trail. 4 March 1998. Elevation 260 m. 10 m elevation below road along main ridge. 75 min (v), 15 min (g).

98.18. Alava ridge. 5 March 1998. Elevation 395 m. Approx. 140 m west of Vatia powerline trail. Opportunistic sample; not part of the quantitative survey.

98.19. Alava ridge. 5 March 1998. Elevation approx. 395 m. 20 m towards powerline from station 98.18. Opportunistic sample; not part of the quantitative survey.

98.20. Maugaloa ridge. 5 March 1998. Elevation approx. 395 m. East of powerline, between powerline and first major peak. Opportunistic sample; not part of the quantitative survey.

98.21. Maugaloa ridge. 5 March 1998. Elevation 392 m. At first major peak east of powerline. 75 min (v), 15 min (g).

98.22. Maugaloa ridge. 5 March 1998. Elevation 415 m. At next peak east of station 98.21. Much *Freycinetia*. 75 min (v), 15 min (g).

98.23. Maugaloa ridge. 5 March 1998. Elevation 405 m. In the eastern end of the dip east of the peak of station 98.21, just as the trail begins to climb again. 75 min (v), 15 min (g).

98.24. Maugaloa ridge. 5 March 1998. Elevation 427 m. At the next peak east of station 98.23. 75 min (v), 15 min (g).

98.25. Maugaloa ridge. 5 March 1998. Elevation 446 m. Down from the peak of station 98.24 to flatter part of the trail, just as the trail begins to climb again. West of the intersection with the top of the Tiatauala ridge trail. 75 min (v), 15 min (g).

98.26. Olo ridge. 6 March 1998. Elevation 234 m. At distinct rocky outcrop. Opportunistic sample; not part of the quantitative survey. Note: this station is higher than station 98.29, although altimeter readings contradict this.

98.27. Maugaloa ridge. 6 March 1998. Elevation 408 m. In dip between the two peaks that mark the intersections of the Olo and Tiatauala ridge trails with the Maugaloa ridge trail. 50 min (v), 10 min (g).

98.28. Olo ridge. 6 March 1998. Elevation 427 m. Top of ridge where trail intersects Maugaloa ridge trail. 70 min (v), 10 min (g).

98.29. Olo ridge. 6 March 1998. Elevation 324 m. 70 min (v), 10 min (g).

98.30. Olo ridge. 6 March 1998. Elevation 238 m. Above trail at seaward base of rock tower. Note: this station is lower than station 98.26, although altimeter readings contradict this. 70 min (v), 10 min (g).

98.31. Olo ridge. 6 March 1998. Elevation 179 m. 70 min (v), 10 min (g).

98.32. Olo ridge. 6 March 1998. Elevation 136 m. Trail here is in banana plantation just outside the National Park boundary; samples taken in native forest just west of the trail, probably just inside the Park boundary. 70 min (v), 10 min (g).

98.33. Muliulu point trail. 7 March 1998. Elevation 18 m. At base of forest back of exposed lava rock. Lot of *Hibiscus*. 30 min (v), 25 min (g)

98.34. Muliulu point trail. 7 March 1998. Elevation 65 m. 70 min (v), 10 min (g).

98.35. Muliulu point trail. 7 March 1998. Elevation 122 m. 70 min (v), 10 min (g).

98.36. Muliulu point trail. 7 March 1998. Elevation 172 m. 70 min (v), 10 min (g).

98.37. Muliulu point trail. 7 March 1998. Elevation 200 m. 70 min (v), 10 min (g).

98.38. Muliulu point trail. 7 March 1998. Elevation 253 m. 19 m elevation below road along main ridge. 70 min (v), 10 min (g).

98.39. Faiga ridge. 9 March 1998. Elevation 81 m. On rocks in fast-flowing stream, just where trail leaves Leafu stream. Freshwater snails. Not part of the land snail survey.

98.40. Faiga ridge. 9 March 1998. Elevation 310 m. Opportunistic sample; not part of the quantitative survey.

98.41. Faiga ridge. 9 March 1998. Elevation 328 m. 70 min (v), 10 min (g).

98.42. Faiga ridge. 9 March 1998. Elevation 266 m. Flagged blue/yellow. 70 min (v), 10 min (g).

98.43. Faiga ridge. 9 March 1998. Elevation 215 m. 70 min (v), 10 min (g).

98.44. Faiga ridge. 9 March 1998. Elevation 160 m. At saddle where trail going down turns right just begfore Mauagotula peak. 70 min (v), 10 min (g).

98.45. Faiga ridge. 9 March 1998. Elevation 67 m. Alongside stream, just opposite side stream with waterfall. 70 min (v), 10 min (g).

98.46. Faiga ridge. 9 March 1998. Elevation 59 m. In stream. Freshwater snails. Not part of the land snail survey.

98.47. Faiga ridge. 9 March 1998. Elevation 2 m. Between beach and coastal track to the west of Vatia village. Opportunistic sample; not part of the quantitative survey.

98.48. Pagatatua ridge. 10 March 1998. Elevation 72 m. At bottom of trail, near where the stream goes over the cliff and into the ocean. 70 min (v), 10 min (g).

98.49. Pagatatua ridge. 10 March 1998. Elevation 125 m. 70 min (v), 10 min (g).

98.50. Pagatatua ridge. 10 March 1998. Elevation 143 m. Opportunistic sample; not part of the quantitative survey.

98.51. Pagatatua ridge. 10 March 1998. Elevation 180 m. 70 min (v), 10 min (g).

98.52. Pagatatua ridge. 10 March 1998. Elevation 227 m. 70 min (v), 10 min (g).

98.53. Pagatatua ridge. 10 March 1998. Elevation 285 m. 70 min (v), 10 min (g).

98.54. Pagatatua ridge. 10 March 1998. Elevation 371 m. Approx. 10 m elevation below road along main ridge. 70 min (v), 10 min (g).

98.55. Vatia powerline trail. 11 March 1998. Elevation 343 m. On Alava/Maugaloa ridge at intersection with Vatia powerline trail. 50 min (v), 10 min (g).

98.56. Vatia powerline trail. 11 March 1998. Elevation 290 m. At point where trail steepens sharply. 50 min (v), 10 min (g).

98.57. Vatia powerline trail. 11 March 1998. Elevation 224 m. 50 min (v), 10 min (g).

98.58. Vatia powerline trail. 11 March 1998. Elevation 170 m. Much nonindigenous vegetation alongside trail. Samples taken in native vegetation just off trail. 50 min (v), 10 min (g).

98.59. Vatia powerline trail. 11 March 1998. Elevation 124 m. Vegetation probably entirely nonindigenous alonside trail. Samples taken just off trail. 50 min (v), 10 min (g).

98.60. Vatia powerline trail. 11 March 1998. Elevation 90 m. Just back up trail from large mango tree. 50 min (v), 10 min (g).

98.61. Toa ridge. 12 March 1998. Elevation 457 m. On Alava/Maugaloa ridge at intersection with Toa ridge. 90 min (v), 10 min (g).

98.62. Alava ridge. 12 March 1998. Elevation 435 m. In first dip along trail east of Toa ridge. 90 min (v), 10 min (g).

98.63. Faiga ridge. 12 March 1998. Elevation 454 m. Top of ridge where trail intersects Maugaloa ridge trail. Flagged blue/yellow. 90 min (v), 10 min (g).

98.64. Alava ridge. 12 March 1998. Elevation 397 m. Relatively flat area (actually a series of small ups and downs) east of station 98.63. 90 min (v), 10 min (g).

98.65. Maatulua ridge. 13 March 1998. Elevation 108 m. Approx. 100 m back up along trail from the bottom end of the trail. 50 min (v), 10 min (g).

98.66. Maatulua ridge. 13 March 1998. Elevation 178 m. 70 min (v), 10 min (g).

98.67. Maatulua ridge. 13 March 1998. Elevation 231 m. 70 min (v), 10 min (g).

98.68. Maatulua ridge. 13 March 1998. Elevation 288 m. 70 min (v), 10 min (g).

98.69. Maatulua ridge. 13 March 1998. Elevation 333 m. 70 min (v), 10 min (g).

98.70. Maatulua ridge. 13 March 1998. Elevation 397 m. Opportunistic sample; not part of the quantitative survey.

98.71. Maatulua ridge. 13 March 1998. Elevation 399 m. 70 min (v), 10 min (g).

98.72. Siufaga point trail. 14 March 1998. Elevation 30 m. 70 min (v), 10 min (g).

98.73. Siufaga point trail. 14 March 1998. Elevation 79 m. 70 min (v), 10 min (g).

98.74. Siufaga point trail. 14 March 1998. Elevation 145 m. 70 min (v), 10 min (g).

98.75. Plantation ridge. 14 March 1998. Elevation 42 m. 70 min (v), 10 min (g).

98.76. Plantation ridge. 14 March 1998. Elevation 82 m. 70 min (v), 10 min (g).

98.77. Plantation ridge. 14 March 1998. Elevation 143 m. 70 min (v), 10 min (g).

98.78. Plantation ridge. 14 March 1998. Elevation 197 m. 70 min (v), 10 min (g).

98.79. Amalau valley. 16 March 1998. Elevation 11 m. Just inland from western end of sandy part of beach. 90 min (v), 10 min (g).

98.80. Amalau valley. 16 March 1998. Elevation 5 m. Just to west of trail running to the beach, approx. 50 m inland. 90 min (v), 10 min (g).

98.152. Leemo ridge. 6 October 1998. Elevation 209 m. 90 min (v), 10 min (g).

98.153. Leemo ridge. 6 October 1998. Elevation 177 m. At end of trail where stream drops over a sheer cliff; some distance inland from the ocean. 90 min (v), 10 min (g).

98.154. Leemo ridge. 6 October 1998. Elevation 270 m. 90 min (v), 10 min (g).

98.155. Leemo ridge. 6 October 1998. Elevation 314 m. 90 min (v), 10 min (g).

98.156. Leemo ridge. 6 October 1998. Elevation 367 m. Approx 11 m elevation below road along main ridge. 90 min (v), 10 min (g). Note: elevation at the road, recorded earlier in the day, was 355 m, but just following sampling at this station was 378 m.

98.157. Levaga ridge. 7 October 1998. Elevation 130 m. Bottom of the trail at end of ridge. Dry, open vegetation. 70 min (v), 10 min (g).

98.158. Levaga ridge. 7 October 1998. Elevation 210 m. 70 min (v), 10 min (g).

98.159. Levaga ridge. 7 October 1998. Elevation 269 m. 70 min (v), 10 min (g).

98.160. Levaga ridge. 7 October 1998. Elevation 305 m. 70 min (v), 10 min (g).

98.161. Levaga ridge. 7 October 1998. Elevation 385 m. 70 min (v), 10 min (g). Flagged blue and yellow as a good *Samoana conica* locality.

98.162. Levaga ridge. 7 October 1998. Elevation 413 m. Approx. 9 m elevation below road along main ridge. 70 min (v), 10 min (g). Note: elevation at the road, recorded earlier in the day, was 406 m, but just following sampling at this station was 422 m.

98.163. Fagatuitui cove trail. 7 October 1998. Elevation 330 m. Approx. 19 m elevation below road along main ridge. 70 min (v), 10 min (g).

98.164. Fagatuitui cove trail. 7 October 1998. Elevation 273 m. 50 min (v), 10 min (g).

98.165. Toa ridge. 8 October 1998. Elevation 330 m. In forest about 50 m back up along trail from large mango tree. 70 min (v), 10 min (g).

98.166. Toa ridge. 8 October 1998. Elevation 52 m. Opportunistic sample; not part of the quantitative survey.

98.167. Toa ridge. 8 October 1998. Elevation 62 m. 70 min (v), 10 min (g).

98.168. Toa ridge. 8 October 1998. Elevation 142 m. Opportunistic sample; not part of the quantitative survey.

98.169. Toa ridge. 8 October 1998. Elevation 193 m. 70 min (v), 10 min (g).

98.170. Toa ridge. 8 October 1998. Elevation 291 m. 70 min (v), 10 min (g). Flagged blue and yellow as a good *Eua zebrina* and *Samoana conica* locality.

98.171. Faiga ridge. 9 October 1998. Elevation 400 m. Opportunistic sample; not part of the quantitative survey.

98.172. Faiga ridge. 9 October 1998. Elevation 288 m. Opportunistic sample; not part of the quantitative survey.

98.173. Faiga-powerline contour. 9 October 1998. Elevation 220 m. Between first and second streams east of Faiga ridge trail. Opportunistic sample; not part of the quantitative survey.

98.174. Faiga-powerline contour. 9 October 1998. Elevation 220 m. Approx. 10 m east of third stream east of Faiga ridge trail. Opportunistic sample; not part of the quantitative survey.

98.175. Faiga-powerline contour. 9 October 1998. Elevation 217 m. At northernmost point of ridge east of fourth stream east of Faiga ridge trail. Opportunistic sample; not part of the quantitative survey.

98.176. Faiga-powerline contour. 9 October 1998. Elevation 217 m. Approx. 30 m north-east of crossing at uppermost eastern branch of Gaoa stream. Opportunistic sample; not part of the quantitative survey.

98.177. Faiga-powerline contour. 9 October 1998. Elevation 218 m. Approx. 55 m farther north-east along contour from station 98.176. Opportunistic sample; not part of the quantitative survey.

98.178. Amalau coast. 10 October 1998. Elevation 8 m. Approx. 200 m northwest along coast from station 98.80. Flagged blue and yellow as a good *Eua zebrina* locality. 100 min (v); ground sample not timed so not part of the quantitative survey.

98.179. Powerline-Matavalu ridge contour. 12 October 1998. Elevation 296 m. Approx 110 m east along contour from Vatia powerline trail. Opportunistic sample; not part of the quantitative survey.

98.180. Tiatauala ridge-Faatafe stream. 13 October 1998. Elevation 259 m. At elevation 379 m on Tiatauala ridge, dropped into valley to west, reached stream at 280 m, headed downstream to 259 m, then west along contour to a very small tributary. Opportunistic sample; not part of the quantitative survey.

98.181. Tiatauala ridge-Faatafe stream. 13 October 1998. Elevation 111 m. On ridge betweem Faatafe stream and Tofu stream. Opportunistic sample; not part of the quantitative survey.

98.182. Polauta ridge. 14 October 1998. Elevation 182 m. Opportunistic sample; not part of the quantitative survey.

98.183. Polauta ridge. 14 October 1998. Elevation 0 m. Northwest side of ridge on rocky shore at end of saddle trail between Polauta and Siuono ridges. Marine snails; not part of the land snail survey.

98.184. Fagatuitui cove trail. 15 October 1998. Elevation 68 m. 110 min (v), 10 min (g).

98.185. Fagatuitui cove trail. 15 October 1998. Elevation 144 m. 110 min (v), 10 min (g).

98.186. Fagatuitui cove trail. 15 October 1998. Elevation 210 m. 110 min (v), 10 min (g).

98.187. Tafuna. 16 October. Not part of National Park survey.

98.188. Amalau valley. 16 October 1998. Elevation 123 m. At base of waterfall on left-hand (looking upstream) fork of stream. Freshwater snails; not part of land snail survey.

APPENDIX 2. TA'Ū: DETAILS OF SAMPLING STATIONS

Station numbers are field numbers of Robert H. Cowie. "98" indicates the year (1998). The second number is the sample station. Elevations are approximate—see text, section 3.1.1. Refer to the map (Figure 4) for location of sites, especially along the Lata mountain trail (stations 98.81–98.98). Sample times (for quantitative samples only, not opportunistic samples) are the total number of person-minutes spent searching vegetation (v) and ground (g).

98.81. Lata mountain trail. 29 April 1998. Elevation 953 m. On the ridge, just east of the highest point of Lata mountain. Snails predominantly on *Freycinetia*. 90 min (v), 10 min (g).

98.82. Lata mountain trail. 29 April 1998. Elevation 933 m. East of station 98.81 in dip along ridge between that station and the next minor peak to the east. Snails predominantly on *Freycinetia*. 90 min (v), 10 min (g).

98.83. Lata mountain trail. 29 April 1998. Elevation 922 m. Farther east from station 98.82 in next dip along ridge. Snails predominantly on *Freycinetia* but also on tree ferns and ti. 90 min (v), 10 min (g).

98.84. Lata mountain trail. 29 April 1998. Elevation 922 m. Farther east from station 98.83 in dipwith thick tall vegetation, just before the point where the trail turns down the mountain. 90 min (v), 10 min (g).

98.85. Lata mountain trail. 30 April 1998. Elevation 832 m. 90 min (v), 10 min (g).

98.86. Lata mountain trail. 30 April 1998. Elevation 797 m. Around campsite. 90 min (v), 10 min (g).

98.87. Lata mountain trail. 30 April 1998. Elevation 720 m. Just as trail enters dry stream bed. Samples taken in vegetation alongside stream. 90 min (v), 10 min (g).

98.88. Lata mountain trail. 30 April 1998. Elevation 626 m. Alongside stream bed, as station 98.87. 90 min (v), 10 min (g).

98.89. Lata mountain trail. 30 April 1998. Elevation 523 m. In forest. Trail not in stream bed. 90 min (v), 10 min (g).

98.90. Lata mountain trail. 30 April 1998. Elevation 463 m. 90 min (v), 10 min (g).

98.91. Lata mountain trail. 30 April 1998. Elevation 403 m. Close to rim of Luatele (Judd's) Crater. 90 min (v), 10 min (g).

98.92. Lata mountain trail. 30 April 1998. Elevation 378 m. Close to rim of Luatele (Judd's) Crater, near campsite. 90 min (v), 10 min (g).

98.93. Luatele crater. 1 May 1998. Elevation 306 m. On crater floor. Habitat very disturbed. Much *Clidemia*. Snails in vegetation only on *Freycinetia*. 90 min (v), 10 min (g).

98.94. Lata mountain trail. 1 May 1998. Elevation 317 m. 90 min (v), 10 min (g).

98.95. Lata mountain trail. 1 May 1998. Elevation 253 m. 90 min (v), 10 min (g).

98.96. Lata mountain trail. 1 May 1998. Elevation 198 m. Habitat very dry. Ti, *Hibiscus*, *Clidemia*, vines. 90 min (v), 10 min (g).

98.97. Lata mountain trail. 1 May 1998. Elevation 143 m. Just as trail going down becomes very steeply sloping above Fitiuta village. Snails in vegetation came from the middle of bird's nest ferns. 90 min (v), 10 min (g).

98.98. Lata mountain trail. 1 May 1998. Elevation 81 m. Snails in vegetation came from the middle of bird's nest ferns. 90 min (v), 10 min (g).

98.99. South coast. 2 May 1998. Elevation 0 m. Marine snails on rocky shore. Not part of land snail survey.

98.100. South coast. 2 May 1998. Elevation 0 m. Marine snails on rocky shore; not part of land snail survey. Ellobiidae; opportunistic land snail sample; not part of the quantitative survey.

98.101. South coast. 2 May 1998. Elevation 17 m. Immediately behind Mataitutua Rock, in vegetation at top of cliff. Vegetation probably subject to a lot of salt spray. Vegetation sample mostly from center of bird's nest ferns. 70 min (v), 10 min (g).

98.102. South coast. 2 May 1998. Elevation 79 m. Directly inland up mountain from station 98.101. Boulder formations make the distinction betwen ground and vegetation habitats difficult to determine. 70 min (v), 10 min (g).

98.103. South coast. 2 May 1998. Elevation 30 m. Just behind Papaloaloa Point in forest at edge of cliff. 70 min (v), 10 min (g).

98.104. South coast. 2 May 1998. Elevation 80 m. Directly inland up mountain from station 98.103. Subulinids in vegetation sample are from the middle of bird's nest fern. 70 min (v), 10 min (g).

98.105. South coast/Laufuti stream. 2 May 1998. Elevation 0 m. At mouth of Laufuti stream as it hits boulders of the beach. Freshwater snails. Not part of the land snail survey.

98.106. South coast/Laufuti stream. 2 May 1998. Elevation 54 m. Alongside stream and on canyon walls near base of high waterfall just inland from coast. 70 min (v), 10 min (g).

98.107. South coast. 2 May 1998. Elevation 3 m. Approx. half way along beach that runs immediately east of Laufuti stream mouth. Samples taken in forest just in back of the beach. *Pythia* in vegetation sample are from the middle of bird's nest fern. 70 min (v), 10 min (g).

98.108. East coast. 3 May 1998. Elevation c. 3 m. At Park boundary, between road and ocean. Opportunistic sample; not part of the quantitative survey.

98.109. East coast. 3 May 1998. Elevation c. 3 m. On opposite side of road from station 98.108. In litter. Ground very dry. Opportunistic sample; not part of the quantitative survey.

98.110. East coast. 3 May 1998. Elevation 2 m. South of stations 98.108 and 98.109. At third concrete stream crossing. Between road and ocean. Opportunistic sample; not part of the quantitative survey.

98.111. East coast. 3 May 1998. Elevation 2 m. On opposite side of road from station 98.110. Under *Barringtonia* and *Hibiscus*. Opportunistic sample; not part of the quantitative survey.

98.112. East coast. 3 May 1998. Elevation 20 m. Approx. 100 m inland from stations 98.110 and 98.111. In middle of bird's nest ferns. Opportunistic sample; not part of the quantitative survey.

98.113. East coast. 3 May 1998. Elevation 2 m. Farther south from stations 98.110 and 98.111; approx. 150 m. beyond large well on inland side of raod. Sample taken between road and shore under *Barringtonia* and *Hibiscus*. Opportunistic sample; not part of the quantitative survey.

98.114. East coast. 3 May 1998. Elevation 2 m. On opposite side of road from station 98.113. Opportunistic sample; not part of the quantitative survey.

98.115. East coast. 3 May 1998. Elevation 4 m. Approx. 50 m inland from station 98.114. On trees. Opportunistic sample; not part of the quantitative survey.

98.116. Saua stream trail. 4 May 1998. Elevation 320 m. On south side of stream. Opportunistic sample; not part of the quantitative survey.

98.117. Saua stream trail. 4 May 1998. Elevation 391 m. In low, thick forest alongside flat streambed, approx. 50 m above top of last waterfall. Two dead shells in vegetation sample were in *Freycinetia* crotches. 70 min (v), 10 min (g).

98.118. Saua stream trail. 4 May 1998. Elevation 341 m. On south side of stream. Dead shell in vegetation sample was in *Freycinetia* crotch. 70 min (v), 10 min (g).

98.119. Saua stream trail. 4 May 1998. Elevation 303 m. Around bamboo thicket just on south side of stream. 70 min (v), 10 min (g).

98.120. Saua stream trail. 4 May 1998. Elevation 236 m. Just on south side of stream. Pig damage. Very dry. 70 min (v), 10 min (g).

98.121. Saua stream trail. 4 May 1998. Elevation 143 m. close to top of lowest major waterfall. On south side of stream. 70 min (v), 10 min (g).

98.122. Siu point. 5 May 1998. Elevation c. 5 m. Ellobiidae at juncture of pebbles and creeping vegetation. Opportunistic sample; not part of the quantitative survey.

98.123. Laufuti stream trail. 5 May 1998. Elevation 433 m. Approx. 300 m upstream above big waterfall. Forest at edge of streambed. Snails mostly on *Freycinetia*. 50 min (v), 10 min (g).

98.124. Laufuti stream trail. 5 May 1998. Elevation 430 m. At top of big waterfall. Forest at edge of streambed (mostly *Freycinetia*). Subulinids in vegetation smaple from the middle of bird's nest fern. Note: elevation difference between stations 98.123 and 98.124 is greater than indicated by the altimeters. A rain shower in the interval between sampling at the two stations may have been associated with pressure change. 50 min (v), 10 min (g).

98.125. Laufuti stream trail. 5 May 1998. Elevation 374 m. At point where trail going down around the big waterfall re-enters the streambed. 50 min (v), 10 min (g).

98.126. Laufuti stream trail. 5 May 1998. Elevation 319 m. At point where trail going down leaves the streambed. Thick, medium-height mixed forest. 70 min (v), 10 min (g).

98.127. Laufuti stream trail. 5 May 1998. Elevation 247 m. Beyond point where the trail leaves the edge of Laufuti stream canyon. Lots of fern. 70 min (v), 10 min (g).

98.128. Laufuti stream trail. 5 May 1998. Elevation 112 m. Good forest but with quite a few ferns. 70 min (v), 10 min (g).

98.129. South coast. 6 May 1998. Elevation 57 m. Immediately inland from station 98.107. Very difficult steep terrain. 70 min (v), 10 min (g). 70 min (v), 10 min (g).

98.130. Laufuti stream trail. 6 May 1998. Elevation 77 m. Good forest with lots of broad-leaved trees. 70 min (v), 10 min (g).

98.131. East coast. 6 May 1998. Elevation 14 m (altimeters reading too high). Approx. 150 m south of stations 98.113, 98.114, 98.115. Just inland from road. 70 min (v), 10 min (g).

98.132. East coast. 6 May 1998. Elevation 22 m (altimeters probably reading too high). In flat area of broken coral below where the rock rises steeply out of the ground. Approx. 100 m inland from road. 70 min (v), 10 min (g).

98.133. Saua stream trail. 6 May 1998. Elevation 28 m. Alongside south side of stream. 70 min (v), 10 min (g).

APPENDIX 3. OFU: DETAILS OF SAMPLING STATIONS

Station numbers are field numbers of Robert H. Cowie. "98" indicates the year (1998). The second number is the sample station. Elevations are approximate—see text, section 3.1.1. Refer to the map (Figure 5) for location of sites. Sample times (for quantitative samples only, not opportunistic samples) are the total number of person-minutes spent searching vegetation (v) and ground (g).

98.134. South coast. 7 May 1998. Elevation 2 m. Ground sample in thin belt of vegetation between road and beach, approx. 600 m inside the Park boundary along the coast road to Olosega. Substrate mostly coral chunks. No vegetation sample taken. 80 min (g).

98.135. South coast. 7 May 1998. Elevation 2 m. Farther towards Olosega from station 98.134. Approx. 200 m beyond distinct rise in road; approx. 100 m beyond large rock on seaward side of road; approx. 20 m before "hurricane house". In strip of vegetation between road and ocean. Substrate is sand. No vegetation sample taken. 80 min (g).

98.136. South coast. 7 May 1998. Elevation 2 m. Farther east along road towards Olosega from station 98.135. At opening in vegetation seaward of the road, just opposite the first abandoned house going towards Olosega, and almost opposite the saddle road between Sunuiatao peak and the main part of Ofu. Under *Scaevola* between road and beach. Substrate is coarse shell/coral sand. No vegetation sample taken. 80 min (g).

98.137. North coast. 7 May 1998. Elevation 2 m. Due north of Sunuitao peak. In vegetation between road and beach, just inland from large rock topped with vegetation, and almost at the point where the road runs along the top of the shore with no intervening vegetation. Not in National Park. 40 min (v), 40 min (g).

98.138. South coast. 7 May 1998. Elevation 2 m. Approx. 250 m south west of the bridge between Ofu and Olosega. One sample under low vegetation approx. 2 m inland from edge of low vegetation. One sample closer to edge of rocks, under trees. No vegetation sample taken. 80 min (g).

98.139. Tumu mountain. 8 May 1998. Elevation 450 m. Approx. 250 m west of radio tower. Apparently on highest point of Tumu mountain. Not in National Park. 90 min (v), 10 min (g).

98.140. Tumu mountain. 8 May 1998. Elevation 443 m. Approx. 100 m west of radio tower. Same area in which the 1992 survey found *Samoana thurstoni*. Faded red flagging still remained. Re-flagged red. Not in National Park. 90 min (v), 10 min (g).

98.141. Tumu mountain. 8 May 1998. Elevation c. 447 m. Opportunistic sample; not part of the quantitative survey. Not in National Park.

98.142. Tumu mountain trail. 8 May 1998. Elevation 323 m. Down trail/road from top of Ofu. Approx. 250 m downhill from a major bend in the road. Then approx. 50 m uphill at 90 degrees to the road through a *Hibiscus* grove and into good native forest. *Hibiscus* flagged red at trail/road. Not in National Park. 90 min (v), 10 min (g).

98.143. Tumu mountain trail. 8 May 1998. Elevation 249 m. Just at the point where the trail/road crosses the saddle over Mako ridge. Narrow inconspicuous side trail to the east opposite two large mango trees. Approx 50 m along side trail through *Hibiscus* and into forest. Not in National Park. 90 min (v), 10 min (g).

98.144. Tumu mountain trail. 8 May 1998. Elevation 166 m. Either side of trail/road at very sharp, acute left had bend in the road going down. Not in National Park. 90 min (v), 10 min (g).

98.145. Sunuitao peak. 9 May 1998. Elevation 120 m. Eastern ridge of Sunuitao peak at base of first small peak. Vegetation very salty and dry. 90 min (v), 10 min (g).

98.146. Sunuitao peak. 9 May 1998. Elevation 79 m. Eastern ridge of Sunuitao peak. Snails on vegetation only found in center of bird's nest fern. 90 min (v), 10 min (g).

98.147. South coast. 9 May 1998. Elevation c. 3 m. Fatuaga Point. Just above shore at the southernmost point of Sunuitao peak where it goes directly into the beach. Sample taken at base of cliff on rocky shore. Terrestrial snail shells obviously fallen down from above. No vegetation sample taken. 100 min (g).

98.148. Sunuitao peak. 9 May 1998. Elevation 99 m. Southwest side of Sunuitao peak. Just below little spigot of rock between the two main peaks. Steep, unstable slope. Snails on vegetation only found in center of bird's nest fern. 90 min (v), 10 min (g).

98.149. Sunuitao peak. 9 May 1998. Elevation 22 m. Southwest side of Sunuitao peak. 90 min (v), 10 min (g).

98.150. South coast. 9 May 1998. Elevation 24 m (altimeters probably reading too high). Approx 0.5 km in the Vaoto Lodge direction from the point at which the road turns inland to go over the saddle between Sunuitao peak and the main part of Ofu. Approx. opposite the middle of the small distinct peak on the ridge of Ofu. Then inland along track approx. 100 m. 90 min (v), 10 min (g).

98.151. South coast. 9 May 1998. Elevation 46 m. Approx. 20 m inside Park boundary. Approx. 20 m upslope from road. Rocky. Snails on vegetation only found in center of bird's nest fern. 70 min (v), 10 min (g).

APPENDIX 4. TUTUILA: NUMBER OF SPECIMENS OF EACH SPECIES COLLECTED AT EACH SAMPLING STATION

Sample numbers are field numbers of Robert H. Cowie. "98" indicates the year (1998). The second number is the sample site. The third number indicates whether the sample was taken from vegetation ("1") or from the ground ("2"). If this third number is lacking, these samples are opportunistic, untimed samples that were not part of the timed, transect-based sampling program (with the exception of 98.178.2, which is also an opportunistic, untimed sample). Numbers in parentheses indicate specimens that were recorded but not collected. A "?" in parentheses indicates that the species was recorded as present but numbers of individuals were not counted. Samples 98.1–98.80 were collected 3–16 March 1998; samples 98.152–98.188 were collected 6–16 October 1998.

Sample #	Species	Number of live specimens	Number of dead specimens	Total
98.1.1	*Pleuropoma beryllina*	16	1	17
98.1.2	*Pleuropoma fulgora*	-	4	4
	Paropeas achatinaceum	-	4	4
	Subulina octona	2	3	5
	Achatina fulica	(?)	(?)	(?)
	Euglandina rosea	-	1	1
	Diastole schmeltziana	-	1	1
98.2.1	no snails seen	-	-	-
98.2.2	Veronicellidae, unidentified	1	-	1
	Allopeas clavulinum	-	1	1
	Euglandina rosea	-	2	2
	Parmarion martensi	1	-	1
98.3.1	*Pleuropoma beryllina*	3	-	3
98.3.2	*Paropeas achatinaceum*	-	4	4
	Allopeas clavulinum	-	1	1
	Subulina octona	1	-	1
	Achatina fulica	(?)	(?)	(?)
98.4	*Pleuropoma beryllina*	3	-	3
	Euglandina rosea	-	1	1
	Parmarion martensi	1	-	1
98.5.1	*Pleuropoma beryllina*	30	-	30
98.5.2	*Pleuropoma beryllina*	-	2	2
	Pleuropoma fulgora	1	7	8
	?Pronesopupa sp.	-	1	1
	Paropeas achatinaceum	-	4	4
	Subulina octona	-	3	3
	Euglandina rosea	-	2	2
98.6.1	*Pleuropoma beryllina*	30	-	30
	Elasmias sp.	3	-	3
	Diastole schmeltziana	1	-	1
98.6.2	*Pleuropoma fulgora*	-	14	14
	Eua zebrina	-	1	1
	Paropeas achatinaceum	-	3	3
	Subulina octona	-	16	16
98.7.1	*Peuropoma beryllina*	23	-	23

	Succinea modesta	1	-	1
	Ovachlamys fulgens	4	-	4
98.7.2	*Pleuropoma fulgora*	-	5	5
	Assiminea parvula	-	1	1
	Paropeas achatinaceum	1	1	2
	Subulina octona	5	9	14
	Euglandina rosea	-	1	1
98.8	*Melampus castaneus*	1	-	1
	Melampus fasciatus	27	-	27
98.9.1	*Pleuropoma beryllina*	63	-	63
	Pleuropoma fulgora	2	-	2
98.9.2	*Pleuropoma beryllina*	1	1	2
	Pleuropoma fulgora	1	-	1
	Assiminea parvula	2	-	2
	Omphalotropis sp. A	2	-	2
	Paropeas achatinaceum	7	2	9
	Subulina octona	20	1	21
	Euglandina rosea	(?)	(?)	(?)
	Succinea modesta	3	-	3
98.10.1	*Pleuropoma beryllina*	44	-	44
98.10.2	*Assiminea parvula*	-	2	2
	Omphalotropis sp. A		2	2
	Paropeas achatinaceum	5	12	17
	Subulina octona	5	4	9
	Achatina fulica	-	(1)	(1)
	Euglandina rosea	1 + (?)	1 +(?)	2 + (?)
	Parmarion martensi	1	-	1
98.11.1	*Pleuropoma beryllina*	15	-	15
	Elasmias sp.	2	-	2
98.11.2	*Paropeas achatinaceum*	17	5	22
	Subulina octona	25	11	36
	Euglandina rosea	-	(?)	(?)
98.12	*Achatina fulica*	(?)	-	(?)
	Euglandina rosea	-	(?)	(?)
	Gonaxis kibweziensis	-	2	2
98.13.1	*Pleuropoma beryllina*	117	-	117
	Veronicellidae, unidentified	1	-	1
	Diastole schmeltziana	1	-	1
98.13.2	*Pleuropoma fulgora*	-	1	1
	Paropeas achatinaceum	10	12	22
	Achatina fulica	2 + (?)	-	2 + (?)
	Euglandina rosea	-	(?)	(?)
	Gonaxis kibweziensis	-	1 + (?)	1 + (?)
	Parmarion martensi	1	-	1
98.14.1	*Pleuropoma beryllina*	85	-	85
	Elasmias sp.	2	-	2
	Diastole schmeltziana	7	-	7
98.14.2	*Pleuropoma beryllina*	1	-	1
	Allopeas clavulinum	2	1	3
	Subulina octona	-	1	1
	Euglandina rosea	-	1	1
	Gonaxis kibweziensis	-	7	7
98.15	*Gonaxis kibweziensis*	-	1	1
	Parmarion martensi	1	-	1

98.16.1	*Pleuropoma beryllina*	49	-	49
	Diastole schmeltziana	4	-	4
98.16.2	*Pleuropoma beryllina*	2	2	4
	Omphalotropis sp. A	-	2	2
	Paropeas achatinaceum	2	-	2
	Achatina fulica	-	(?)	(?)
	Euglandina rosea	-	1 + (?)	1 + (?)
	Gonaxis kibweziensis	-	3	3
	Succinea modesta	1	-	1
	Diastole schmeltziana	-	2	2
98.17.1	*Pleuropoma beryllina*	93	-	93
	Diastole schmeltziana	6	-	6
98.17.2	*Pleuropoma beryllina*	-	8	8
	Pleuropoma fulgora	-	4	4
	Paropeas achatinaceum	-	3	3
	Euglandina rosea	-	2	2
	Gonaxis kibweziensis	-	1	1
	Succinea modesta	-	3	3
	Diastole schmeltziana	-	5	5
98.18	*Eua zebrina*	(1)	1	(1) + 1
	Samoana abbreviata	(1)	1	(1) + 1
	Samoana conica	(3)	-	(3)
98.19	*Eua zebrina*	(1)	1	(1) + 1
98.20	*Samoana abbreviata*	-	1	1
	Paropeas achatinaceum	-	1	1
	Gonaxis kibweziensis	-	2	2
	Diastole schmeltziana	-	1	1
98.21.1	*Pleuropoma beryllina*	-	26	26
	Paropeas achatinaceum	1	-	1
98.21.2	*Pleuropoma fulgora*	-	1	1
	Samoana conica	-	1	1
	Paropeas achatinaceum	3	8	11
	Subulina octona	-	2	2
98.22.1	*Pleuropoma beryllina*	3	-	3
	Pleuropoma fulgora	1	-	1
98.22.2	Veronicellidae, unidentified	1	-	1
	Paropeas achatinaceum	1	18	19
	Euglandina rosea	-	1	1
	Gonaxis kibweziensis	-	1	1
98.23.1	*Pleuropoma beryllina*	41	-	41
	Pleuropoma fulgora	4	-	4
	Eua zebrina	(3)	-	(3)
98.23.2	*Pleuropoma fulgora*	1	-	1
	Eua zebrina	-	1	1
	Samoana abbreviata	-	1	1
	Paropeas achatinaceum	-	7	7
	Achatina fulica	-	(1)	(1)
	Gonaxis kibweziensis	-	1	1
98.24.1	*Pleuropoma fulgora*	1	-	1
	Pleuropoma beryllina	13	-	13
98.24.2	*Pleuropoma beryllina*	-	4	4
	Pleuropoma fulgora	-	2	2
	Paropeas achatinaceum	1	14	15
	Euglandina rosea	(1)	(6)	(7)

	Gonaxis kibweziensis	-	5	5
	Diastole schmeltziana	-	1	1
98.25.1	*Pleuropoma beryllina*	66	-	66
	Diastole schmeltziana	1	-	1
98.25.2	*Pleuropoma beryllina*	-	6	6
	Pleuropoma fulgora	-	4	4
	Paropeas achatinaceum	-	2	2
	Euglandina rosea	-	1 + (1)	1 + (1)
	Gonaxis kibweziensis	-	7	7
	Diastole schmeltziana	-	2	2
98.26	*Eua zebrina*	-	1	1
	Achatina fulica	-	(?)	(?)
	Euglandina rosea	-	(?)	(?)
98.27.1	*Pleuropoma beryllina*	19	-	19
98.27.2	*Pleuropoma beryllina*	-	1	1
	Pleuropoma fulgora	-	1	1
	Paropeas achatinaceum	-	1	1
	Subulina octona	-	1	1
	Euglandina rosea	-	1	1
	Parmarion martensi	1	1	2
98.28.1	*Pleuropoma beryllina*	5	-	5
	Pleuropoma fulgora	1	-	1
98.28.2	*Paropeas achatinaceum*	-	1	1
	Subulina octona	-	3	3
	Euglandina rosea	-	2	2
	Parmarion martensi	1	-	1
98.29.1	*Pleuropoma beryllina*	109	-	109
	Elasmias sp.	1	-	1
	Diastole schmeltziana	1	-	1
98.29.2	*Pleuropoma beryllina*	-	1	1
	Pleuropoma fulgora	-	5	5
	Paropeas achatinaceum	-	7	7
	Allopeas clavulinum	-	2	2
	Subulina octona	3	16	19
98.30.1	*Pleuropoma beryllina*	65	-	65
98.30.2	*Pleuropoma fulgora*	-	1	1
	Eua zebrina	-	1	1
	Paropeas achatinaceum	16	4	20
	Subulina octona	6	5	11
	Euglandina rosea	-	1 + (4)	1 + (4)
98.31.1	*Pleuropoma beryllina*	110	-	110
	Elasmias sp.	20	-	20
	Liardetia samoensis	1	-	1
98.31.2	*Pleuropoma beryllina*	-	1	1
	Pleuropoma fulgora	-	5	5
	Eua zebrina	-	2	2
	Paropeas achatinaceum	7	15	22
	Subulina octona	5	22	27
	Achatina fulica	-	(2)	(2)
	Euglandina rosea	-	(8)	(8)
98.32.1	*Pleuropoma beryllina*	102	-	102
	Pleuropoma fulgora	1	-	1
	Eua zebrina	(1)	-	(1)
	Succinea modesta	10	-	10

98.32.2	*Pleuropoma beryllina*	-	2	2
	Pleuropoma fulgora	-	7	7
	Omphalotropis sp. A	-	10	10
	Eua zebrina	-	6	6
	Subulina octona	-	1	1
	Achatina fulica	-	(?)	(?)
	Streptostele musaecola	-	2	2
	Succinea modesta	-	7	7
98.33.1	*Orobophana musiva*	1	-	1
	Pleuropoma beryllina	12	-	12
98.33.2	*Orobophana musiva*	1	1	2
	Pleuropoma beryllina	-	2	2
	Ostodes adjunctus	-	1	1
	Veronicellidae, unidentified	2	-	2
	Paropeas achatinaceum	5	26	31
	Subulina octona	17	14	31
	Achatina fulica	-	(1)	(1)
	Euglandina rosea	-	(1)	(1)
	Gonaxis kibweziensis	1	1	2
98.34.1	*Pleuropoma beryllina*	123	-	123
	Pleuropoma fulgora	1	-	1
98.34.2	*Pleuropoma beryllina*	-	2	2
	Pleuropoma fulgora	-	1	1
	Assiminea parvula	-	1	1
	Paropeas achatinaceum	-	1	1
	Allopeas clavulinum	-	1	1
	Subulina octona	-	31	31
	Achatina fulica	-	(1)	(1)
	Euglandina rosea	-	(5)	(5)
	Gonaxis kibweziensis	1	7	8
	Succinea modesta	-	1	1
98.35.1	*Pleuropoma beryllina*	97	-	97
	Pleuropoma fulgora	1	-	1
98.35.2	*Orobophana musiva*	-	6	6
	Pleuropoma beryllina	-	2	2
	Pleuropoma fulgora	-	6	6
	Veronicellidae, unidentified	1	-	1
	Subulina octona	1	10	11
	Euglandina rosea	-	(3)	(3)
	Gonaxis kibweziensis	2	2	4
98.36.1	*Pleuropoma beryllina*	197	-	197
	Pleuropoma fulgora	1	-	1
98.36.2	*Orobophana musiva*	2	-	2
	Pleuropoma fulgora	3	3	6
	Paropeas achatinaceum	4	1	5
	Subulina octona	9	4	13
	Ovachlamys fulgens	1	-	1
98.37.1	*Pleuropoma beryllina*	152	-	152
	Eua zebrina	1 + (1)	-	1 + (1)
	Diastole schmeltziana	3	-	3
	Ovachlamys fulgens	2	-	2
98.37.2	*Pleuropoma fulgora*	1	1	2
	Parmarion martensi	1	-	1
	Paropeas achatinaceum	3	-	3

	Allopeas clavulinum	1	-	1
	Subulina octona	4	1	5
	Achatina fulica	-	(1)	(1)
	Gonaxis kibweziensis	1	1	2
98.38.1	*Pleuropoma beryllina*	155	-	155
	Diastole schmeltziana	1	-	1
98.38.2	*Pleuropoma fulgora*	6	5	11
	Assiminea parvula	10	-	10
	Omphalotropis sp. A	5	1	6
	Paropeas achatinaceum	5	-	5
	Subulina octona	8	2	10
	Achatina fulica	-	(1)	(1)
	Diastole schmeltziana	-	1	1
[98.39]	[*Neritina* sp. A–freshwater	15	-	15]
	[*Neritina* sp. B–freshwater	1	-	1]
	[*Septaria* sp.–freshwater	5	-	5]
	[Thiaridae, unidentified–freshwater	3	-	3]
98.40	*Parmarion martensi*	1	-	1
98.41.1	*Pleuropoma beryllina*	21	-	21
	Pleuropoma fulgora	1	-	1
	Samoana conica	(5)	-	(5)
	Diastole schmeltziana	1	-	1
98.41.2	Veronicellidae, unidentified	1	-	1
	Paropeas achatinaceum	3	2	5
	Subulina octona	-	3	3
	Succinea modesta	1	-	1
	Diastole schmeltziana	-	1	1
98.42.1	*Pleuropoma beryllina*	38	-	38
	Elasmias sp.	1	-	1
	Eua zebrina	(4)	-	(4)
	Samoana conica	(26)	-	(26)
	Diastole schmeltziana	5	-	5
98.42.2	*Pleuropoma beryllina*	-	1	1
	Samoana conica	-	4	4
	Paropeas achatinaceum	-	3	3
98.43.1	*Pleuropoma beryllina*	81	-	81
	Eua zebrina	(3)	-	(3)
	Samoana conica	(1)	-	(1)
	Diastole schmeltziana	2	-	2
98.43.2	*Pleuropoma fulgora*	2	-	2
	Paropeas achatinaceum	2	4	6
	Subulina octona	1	2	3
98.44.1	*Pleuropoma beryllina*	50	-	50
	Eua zebrina	(2)	-	(2)
	Samoana abbreviata	(1)	-	(1)
98.44.2	*Pleuropoma fulgora*	3	-	3
	Paropeas achatinaceum	4	-	4
	Subulina octona	7	-	7
98.45.1	*Pleuropoma beryllina*	57	-	57
98.45.2	*Vaginulus plebeius*	1	-	1
	Allopeas clavulinum	1	1	2
	Subulina octona	-	6	6
	Euglandina rosea	-	(1)	(1)
	Gonaxis kibweziensis	1	3	4

[98.46]	[*Neritina* sp. C–freshwater	1	-	1]
98.47	*Melampus fasciatus*	18	-	18
98.48.1	*Pleuropoma beryllina*	16	-	16
	Veronicellidae, unidentified	1	-	1
	Elasmias sp.	2	-	2
	Eua zebrina	2 + (25)	-	2 + (25)
	Succinea modesta	1	-	1
	Diastole schmeltziana	1	-	1
98.48.2	*Laevicaulis alte*	1	-	1
	Vaginulus plebeius	3	-	3
	Veronicellidae, unidentified	(3)	-	(3)
	Paropeas achatinaceum	1	-	1
	Subulina octona	38	1	39
	Achatina fulica	(3)	-	(3)
98.49.1	*Pleuropoma beryllina*	84	-	84
	Veronicellidae, unidentified	1	-	1
	Eua zebrina	(2)	-	(2)
	Diastole schmeltziana	6	-	6
98.49.2	Veronicellidae, unidentified	1	-	1
	Samoana abbreviata	-	1	1
	Samoana conica	-	2	2
	Gonaxis kibweziensis	-	2	2
98.50	*Samoana conica*	-	1	1
	Euglandina rosea	-	1	1
98.51.1	*Pleuropoma beryllina*	57	-	57
	Elasmias sp.	13	-	13
98.51.2	*Pleuropoma fulgora*	-	2	2
	Paropeas achatinaceum	2	-	2
	Allopeas clavulinum	-	1	1
	Subulina octona	-	1	1
	Succinea modesta	-	1	1
	Diastole schmeltziana	-	1	1
98.52.1	*Pleuropoma beryllina*	75	-	75
	Elasmias sp.	3	-	3
	Samoana conica	(4)	-	(4)
	Diastole schmeltziana	3	-	3
98.52.2	*Pleuropoma beryllina*	-	1	1
	Pleuropoma fulgora	-	1	1
	Vaginulus plebeius	1	-	1
	Paropeas achatinaceum	-	5	5
	Allopeas clavulinum	-	1	1
	Subulina octona	-	2	2
	Euglandina rosea	-	(1)	(1)
98.53.1	*Pleuropoma beryllina*	75	-	75
	Paropeas achatinaceum	1	-	1
	Samoana conica	(2)	-	(2)
	Diastole schmeltziana	6	-	6
98.53.2	*Paropeas achatinaceum*	1	1	2
	Subulina octona	-	3	3
98.54.1	*Pleuropoma beryllina*	2	-	2
	Samoana conica	(4)	-	(4)
98.54.2	*Paropeas achatinaceum*	1	1	2
	Subulina octona	-	1	1
98.55.1	*Pleuropoma beryllina*	42	-	42

	Eua zebrina	(8)	-	(8)
	Samoana abbreviata	(1)	-	(1)
	Samoana conica	(11)	-	(11)
	Achatina fulica	(3)	-	(3)
	Diastole schmeltziana	1	-	1
98.55.2	*Pleuropoma fulgora*	2	2	4
	Paropeas achatinaceum	4	3	7
	Subulina octona	4	1	5
	Achatina fulica	-	1	1
98.56.1	*Pleuropoma beryllina*	64	-	64
	Eua zebrina	(2)	-	(2)
	Samoana abbreviata	(1)	-	(1)
	Diastole schmeltziana	1	-	1
98.56.2	*Paropeas achatinaceum*	13	4	17
	Allopeas clavulinum	-	2	2
	Subulina octona	-	1	1
98.57.1	*Pleuropoma beryllina*	61	-	61
98.57.2	Veronicellidae, unidentified	1	-	1
	Allopeas clavulinum	4	-	4
	Subulina octona	-	1	1
	Achatina fulica	-	(1)	(1)
	Gonaxis kibweziensis	1	-	1
	Liardetia samoensis	3	-	3
98.58.1	*Pleuropoma beryllina*	49	-	49
	Veronicellidae, unidentified	1	-	1
98.58.2	*Pleuropoma fulgora*	-	1	1
	Subulina octona	-	5	5
	Achatina fulica	-	(3)	(3)
	Euglandina rosea	-	(1)	(1)
	Gonaxis kibweziensis	-	2	2
98.59.1	*Pleuropoma beryllina*	28	-	28
	Elasmias sp.	1	-	1
98.59.2	*Orobophana musiva*	-	1	1
	Pleuropoma fulgora	-	5	5
	Pleuropoma beryllina	-	2	2
	Assiminea parvula	-	1	1
	Subulina octona	-	2	2
	Gonaxis kibweziensis	1	4	5
98.60.1	no snails seen	-	-	-
98.60.2	*Omphalotropis* sp. A	-	1	1
	Laevicaulis alte	1	-	1
	Subulina octona	-	6	6
	Euglandina rosea	-	1	1
	Gonaxis kibweziensis	2	5	7
	Succinea modesta	-	1	1
98.61.1	*Pleuropoma beryllina*	49	-	49
	Eua zebrina	(1)	-	(1)
	Diastole schmeltziana	8	-	8
	Ovachlamys fulgens	7	-	7
98.61.2	*Pleuropoma beryllina*	-	2	2
	Paropeas achatinaceum	4	16	20
	Ovachlamys fulgens	3	1	4
98.62.1	*Pleuropoma beryllina*	7	-	7
	Eua zebrina	1 + (10)	-	1 + (10)

	Diastole schmeltziana	8	-	8
98.62.2	*Pleuropoma beryllina*	-	1	1
	Pleuropoma fulgora	-	4	4
	Eua zebrina	-	3	3
	Paropeas achatinaceum	1	22	23
	Achatina fulica	(3)	3 + (1)	3 + (4)
	Gonaxis kibweziensis	-	1	1
98.63.1	*Pleuropoma beryllina*	4	-	4
	Eua zebrina	(16)	-	(16)
	Samoana conica	(1)	-	(1)
	Diastole schmeltziana	7	-	7
	Ovachlamys fulgens	9	-	9
98.63.2	*Pleuropoma fulgora*	1	3	4
	Eua zebrina	-	4	4
	Paropeas achatinaceum	3	29	32
	Euglandina rosea	-	(2)	(2)
	Gonaxis kibweziensis	-	1	1
	Diastole schmeltziana	-	1	1
	Ovachlamys fulgens	1	-	1
98.64.1	*Pleuropoma beryllina*	38	-	38
	Pleuropoma fulgora	2	1	3
	Eua zebrina	1 +(40)	-	1 + (40)
	Samoana abbreviata	(1)	-	(1)
	Samoana conica	(11)	-	(11)
	Diastole schmeltziana	2	-	2
	Ovachlamys fulgens	4	-	4
98.64.2	*Pleuropoma beryllina*	-	1	1
	Pleuropoma fulgora	1	-	1
	Samoana conica	-	3	3
	Paropeas achatinaceum	7	12	19
	Subulina octona	1	1	2
	Achatina fulica	(4)	(1)	(5)
	Gonaxis kibweziensis	-	1	1
	Ovachlamys fulgens	1	-	1
98.65.1	*Pleuropoma beryllina*	32	-	32
	Elasmias sp.	34	-	34
	Eua zebrina	(1)	-	(1)
98.65.2	*Pleuropoma fulgora*	-	8	8
	Eua zebrina	-	2	2
	Paropeas achatinaceum	1	-	1
	Subulina octona	-	3	3
	Achatina fulica	-	1 + (5)	1 + (5)
	Euglandina rosea	-	(3)	(3)
98.66.1	*Pleuropoma beryllina*	102	1	103
	Elasmias sp.	4	-	4
	Eua zebrina	(3)	-	(3)
	Diastole schmeltziana	8	-	8
98.66.2	*Pleuropoma fulgora*	-	3	3
	Pleuropoma	-	1	1
	Paropeas achatinaceum	1	2	3
	Allopeas clavulinum	-	2	2
	Subulina octona	-	3	3
	Diastole schmeltziana	-	1	1
	Liardetia samoensis	-	1	1

98.67.1	*Pleuropoma beryllina*	49	-	49
	Elasmias sp.	1	-	1
	Diastole schmeltziana	4	-	4
98.67.2	*Pleuropoma fulgora*	-	9	9
	Paropeas achatinaceum	-	3	3
	Allopeas clavulinum	-	1	1
	Subulina octona	-	1	1
	Euglandina rosea	-	1	1
	Diastole schmeltziana	1	1	2
98.68.1	*Pleuropoma beryllina*	82	-	82
	Diastole schmeltziana	4	-	4
	Ovachlamys fulgens	1	-	1
98.68.2	*Pleuropoma beryllina*	-	1	1
	Pleuropoma fulgora	-	3	3
	Paropeas achatinaceum	-	2	2
	Allopeas clavulinum	1	-	1
98.69.1	*Pleuropoma beryllina*	25	-	25
98.69.2	*Pleuropoma fulgora*	-	1	1
	Paropeas achatinaceum	-	1	1
	Subulina octona	-	2	2
98.70	*Samoana conica*	-	2	2
98.71.1	*Pleuropoma beryllina*	2	-	2
	Pleuropoma fulgora	1	-	1
	Samoana conica	(2)	-	(2)
	Diastole schmeltziana	11	-	11
98.71.2	*Pleuropoma beryllina*	-	1	1
	Pleuropoma fulgora	-	1	1
	Laevicaulis alte	1	-	1
	Samoana conica	-	2	2
	Paropeas achatinaceum	-	1	1
	Subulina octona	-	1	1
	Diastole schmeltziana	-	1	1
98.72.1	*Pleuropoma beryllina*	49	-	49
	Veronicellidae, unidentified	1	-	1
	Subulina octona	1	-	1
	Ovachlamys fulgens	3	-	3
98.72.2	*Assiminea parvula*	-	1	1
	Omphalotropis sp. A	-	1	1
	Paropeas achatinaceum	-	9	9
	Subulina octona	24	5	29
	Achatina fulica	(1)	-	(1)
98.73.1	*Pleuropoma beryllina*	124	-	124
	Elasmias sp.	3	-	3
98.73.2	*Pleuropoma beryllina*	1	-	1
	Pleuropoma fulgora	1	-	1
	Paropeas achatinaceum	16	2	18
	Allopeas clavulinum	2	-	2
	Subulina octona	3	1	4
	Achatina fulica	(1)	(3)	(4)
	Euglandina rosea	-	(11)	(11)
98.74.1	*Pleuropoma beryllina*	56	-	56
	Pleuropoma fulgora	1	-	1
98.74.2	*Omphalotropis* sp. A	-	2	2
	Paropeas achatinaceum	4	6	10

	Subulina octona	11	9	20
	Gonaxis kibweziensis	-	2	2
98.75.1	*Orobophana musiva*	1	-	1
	Pleuropoma beryllina	137	-	137
	Pleuropoma fulgora	3	-	3
	Succinea modesta	4	-	4
	Ovachlamys fulgens	6	-	6
98.75.2	*Orobophana musiva*	4	7	11
	Pleuropoma beryllina	-	1	1
	Pleuropoma fulgora	-	2	2
	Assiminea parvula	-	1	1
	Subulina octona	4	5	9
	Gonaxis kibweziensis	1	-	1
	Ovachlamys fulgens	3	-	3
98.76.1	*Pleuropoma beryllina*	84	-	84
	Ovachlamys fulgens	1	-	1
98.76.2	*Orobophana musiva*	1	3	4
	Pleuropoma fulgora	1	7	8
	Subulina octona	-	2	2
	Achatina fulica	-	1	1
	Euglandina rosea	-	1	1
	Gonaxis kibweziensis	1	-	1
98.77.1	*Pleuropoma beryllina*	169	-	169
	Pleuropoma fulgora	3	-	3
	Omphalotropis sp. A	1	-	1
	Diastole schmeltziana	6	-	6
	Ovachlamys fulgens	1	-	1
98.77.2	*Omphalotropis musiva*	1	6	7
	Pleuropoma beryllina	-	2	2
	Pleuropoma fulgora	3	7	10
	Assiminea parvula	1	2	3
	Omphalotropis sp. A	-	2	2
	Subulina octona	1	4	5
	Euglandina rosea	-	1	1
	Gonaxis kibweziensis	2	2	4
98.78.1	*Pleuropoma beryllina*	190	-	190
	Pleuropoma fulgora	1	-	1
	Diastole schmeltziana	1	-	1
98.78.2	*Pleuropoma fulgora*	7	-	7
	Orobophana musiva	2	-	2
	Subulina octona	7	1	8
	Ouagapia gradata	1	-	1
98.79.1	*Eua zebrina*	(97)	-	(97)
	Trochomorpha apia	(29)	-	(29)
98.79.2	*Orobophana musiva*	6	1	7
	Pleuropoma fulgora	1	-	1
	Melampus fasciatus	1	-	1
	Pythia scarabaeus	-	2	2
	Subulina octona	-	6	6
	Eua zebrina	-	12	12
	Achatina fulica	-	(3)	(3)
	Euglandina rosea	-	(1)	(1)
	Trochomorpha apia	-	1	1
98.80.1	*Pleuropoma beryllina*	1	-	1

	Eua zebrina	(181)	-	(181)
	Samoana conica	(31)	-	(31)
98.80.2	*Pleuropoma fulgora*	-	1	1
	Orobophana musiva	3	-	3
	Ostodes adjunctus	-	1	1
	Assiminea parvula	2	-	2
	Pythia scarabaeus	-	5 + (4)	5 + (4)
	Eua zebrina	-	11	11
	Samoana conica	-	1	1
	Achatina fulica	(1)	1	1 + (1)
	Euglandina rosea	(1)	-	(1)
98.152.1	*Pleuropoma beryllina*	67	-	67
	Elasmias sp.	33	-	33
	Eua zebrina	(5)	-	(5)
	Diastole schmeltziana	19	-	19
98.152.2	*Pleuropoma fulgora*	-	1	1
	Pleuropoma beryllina	-	1	1
	Eua zebrina	-	1	1
	Paropeas achatinaceum	2	10	12
	Subulina octona	1	2	3
	Diastole schmeltziana	-	1	1
	Liardetia samoensis	-	1	1
98.153.1	*Pleuropoma beryllina*	43	-	43
	Elasmias sp.	3	-	3
	Eua zebrina	(4)	-	(4)
	Diastole schmeltziana	24	-	24
98.153.2	*Paropeas achatinaceum*	5	-	5
	Subulina octona	3	2	5
98.154.1	*Pleuropoma beryllina*	69	-	69
	Elasmias sp.	2	-	2
	Euglandina rosea	1	-	1
	Diastole schmeltziana	31	-	31
98.154.2	*Pleuropoma fulgora*	-	2	2
	Veronicellidae, unidentified	1	-	1
	Eua zebrina	-	1	1
	Paropeas achatinaceum	4	3	7
	Achatina fulica	-	(1)	(1)
98.155.1	*Pleuropoma beryllina*	75	-	75
	Elasmias sp.	1	-	1
	Samoana	(2)	-	(2)
	Diastole schmeltziana	30	-	30
98.155.2	*Paropeas achatinaceum*	3	6	9
	Subulina octona	-	3	3
	Euglandina rosea	-	2	2
98.156.1	*Pleuropoma beryllina*	32	-	32
	Diastole schmeltziana	16	-	16
98.156.2	*Allopeas clavulinum*	1	-	1
	Paropeas achatinaceum	5	-	5
	Subulina octona	3	-	3
	Parmarion martensi	-	1	1
98.157.1	*Pleuropoma beryllina*	21	-	21
	Elasmias sp.	31	1	32
	Eua zebrina	(16)	-	(16)
	Diastole schmeltziana	2	-	2

98.157.2	*Orobophana musiva*	-	1	1
	Paropeas achatinaceum	8	7	15
	Subulina octona	5	4	9
	Euglandina rosea	-	1 + (1)	1 + (1)
	Succinea modesta	-	1	1
	Liardetia samoensis	1	-	1
98.158.1	*Pleuropoma beryllina*	65	-	65
	Elasmias sp.	12	-	12
	Diastole schmeltziana	13	-	13
98.158.2	*Pleuropoma fulgora*	2	22	24
	Pleuropoma beryllina	-	1	1
	Succinea modesta	-	1	1
98.159.1	*Pleuropoma beryllina*	55	-	55
	Elasmias sp.	4	-	4
	Samoana conica	(1)	-	(1)
	Diastole schmeltziana	3	-	3
98.159.2	*Pleuropoma fulgora*	-	7	7
	Paropeas achatinaceum	4	9	13
	Subulina octona	1	3	4
98.160.1	*Pleuropoma beryllina*	64	-	64
	Elasmias sp.	8	-	8
	Samoana conica	(3)	-	(3)
	Diastole schmeltziana	13	-	13
98.160.2	*Pleuropoma fulgora*	-	2	2
	Pleuropoma beryllina	-	2	2
	Veronicellidae, unidentified	1	-	1
	Eua zebrina	-	1	1
	Samoana abbreviata	-	1	1
	Paropeas achatinaceum	1	2	3
	Subulina octona	-	2	2
	Euglandina rosea	-	2	2
	Diastole schmeltziana	-	2	2
98.161.1	*Pleuropoma beryllina*	7	-	7
	Samoana conica	(19)	-	(19)
98.161.2	*Paropeas achatinaceum*	8	-	8
	Subulina octona	2	1	3
98.162.1	*Pleuropoma beryllina*	-	1	1
	Diastole schmeltziana	37	-	37
98.162.2	*Pleuropoma beryllina*	-	1	1
	Allopeas clavulinum	-	1	1
	Paropeas achatinaceum	2	2	4
	Subulina octona	4	-	4
	Euglandina rosea	-	2	2
	Diastole schmeltziana	-	1	1
98.163.1	*Pleuropoma beryllina*	91	-	91
	Elasmias sp.	4	-	4
	Diastole schmeltziana	10	-	10
98.163.2	*Pleuropoma fulgora*	-	5	5
	Pleuropoma beryllina	1	1	2
	Assiminea parvula	7	1	8
	Omphalotropis sp. A	-	5	5
	Paropeas achatinaceum	4	7	11
	Subulina octona	6	10	16
	Euglandina rosea	-	1	1

	Diastole schmeltziana	-	2	2
98.164.1	*Pleuropoma beryllina*	85	-	85
	Samoana conica	(3)	-	(3)
	Diastole schmeltziana	5	-	5
98.164.2	*Pleuropoma beryllina*	-	2	2
	Pleuropoma fulgora	-	3	3
	Paropeas achatinaceum	4	8	12
	Achatina fulica	(3)	1	1 + (3)
98.165.1	*Pleuropoma beryllina*	28	-	28
	Samoana abbreviata	(1)	-	(1)
	Diastole schmeltziana	9	-	9
98.165.2	*Pleuropoma beryllina*	-	1	1
	Allopeas clavulinum	2	1	3
	Paropeas achatinaceum	-	2	2
	Subulina octona	3	2	5
	Achatina fulica	-	(1)	(1)
	Euglandina rosea	1	1	2
	Ovachlamys fulgens	1	-	1
	Parmarion martensi	-	1	1
98.166	*Eua zebrina*	(4)	1	1 + (4)
98.167.1	*Eua zebrina*	(1)	-	(1)
98.167.2	*Allopeas clavulinum*	1	-	1
	Paropeas achatinaceum	16	8	24
	Subulina octona	1	3	4
98.168	*Eua zebrina*	-	1	1
	Achatina fulica	-	1	1
98.169.1	*Pleuropoma beryllina*	28	-	28
	Elasmias sp.	2	-	2
	Eua zebrina	(23)	-	(23)
	Samoana abbreviata	(2)	-	(2)
	Samoana conica	(2)	-	(2)
	Diastole schmeltziana	1	-	1
98.169.2	*Pleuropoma fulgora*	2	4	6
	Paropeas achatinaceum	1	7	8
	Subulina octona	-	3	3
	Achatina fulica	-	(2)	(2)
	Diastole schmeltziana	-	1	1
	Liardetia samoensis	-	1	1
98.170.1	*Pleuropoma beryllina*	8	-	8
	Elasmias sp.	1	-	1
	Eua zebrina	(33)	-	(33)
	Samoana conica	(12)	-	(12)
	Diastole schmeltziana	6	-	6
98.170.2	*Pleuropoma fulgora*	10	13	23
	Allopeas clavulinum	-	1	1
	Paropeas achatinaceum	2	2	4
	Subulina octona	2	2	4
	Achatina fulica	-	1	1
	Euglandina rosea	-	1	1
98.171	*Gonaxis kibweziensis*	-	1	1
98.172	*Euglandina rosea*	-	1	1
98.173	*Gonaxis kibweziensis*	-	1	1
98.174	*Eua zebrina*	(2)	1	(2) + 1
98.175	*Eua zebrina*	(2)	2	(2) + 2

98.176	*Eua zebrina*	(3)	1	(3) + 1
	Samoana conica	(1)	-	(1)
98.177	*Eua zebrina*	(4)	1	(4) + 1
98.178.1	*Eua zebrina*	(201)	-	(201)
98.178.2	*Eua zebrina*	-	1	1
	Achatina fulica	-	(1)	(1)
	Euglandina rosea	-	1	1
98.179	*Eua zebrina*	(2)	1	(2) + 1
98.180	*Eua zebrina*	-	1	1
	Achatina fulica	-	(1)	(1)
	Euglandina rosea	-	1	1
98.181	*Omphalotropis* sp. A	-	1	1
	Euglandina rosea	-	7	7
	Gonaxis kibweziensis	-	2	2
98.182	*Eua zebrina*	(1)	-	(1)
	Samoana abbreviata	-	1	1
[98.183]	[*Nerita maculata*–marine	6	-	6]
	[*Planaxis nigra*–marine	7	-	7]
98.184.1	*Pleuropoma beryllina*	94	-	94
	Diastole schmeltziana	1	-	1
98.184.2	*Pleuropoma fulgora*	2	5	7
	Subulina octona	3	4	7
	Achatina fulica	-	(1)	(1)
	Euglandina rosea	(1)	1	(1) + 1
	Ovachlamys fulgens	1	-	1
98.185.1	*Pleuropoma beryllina*	124	-	124
	Diastole schmeltziana	1	1	2
98.185.2	Veronicellidae, unidentified	1	-	1
	Paropeas achatinaceum	3	7	10
	Subulina octona	2	4	6
	Euglandina rosea	-	2	2
98.186.1	*Pleuropoma beryllina*	99	-	99
	Elasmias sp.	6	-	6
	Samoana conica	(1)	-	(1)
	Diastole schmeltziana	3	-	3
98.186.2	*Pleuropoma fulgora*	1	-	1
	Pleuropoma beryllina	-	10	10
	Paropeas achatinaceum	9	9	18
	Subulina octona	2	-	2
	Achatina fulica	-	1	1
	Parmarion martensi	1	-	1
[98.187]	[Veronicellidae, unidentified	(3) + 1	-	(3) + 1]
[98.188]	[*Neritina* sp. A–freshwater	9	-	9]
	[*Septaria* sp.–freshwater	8	-	8]
	[Thiaridae, unidentified–freshwater	4	-	4]

APPENDIX 5. TA'Ū: NUMBER OF SPECIMENS OF EACH SPECIES COLLECTED AT EACH SAMPLING STATION

Sample numbers are field numbers of Robert H. Cowie. "98" indicates the year (1998). The second number is the sample site. The third number indicates whether the sample was taken from vegetation ("1") or from the ground ("2"), and, in a single instance (98.86.3) an additional sample taken at the site. If this third number is lacking, these samples are opportunistic, untimed samples that were not part of the quantitative, timed sampling program. Numbers in parentheses indicate specimens that were recorded but not collected. Samples in square brackets are not part of the land snail survey, but are incidental marine or freshwater samples.

Sample #	Species	Number of live specimens	Number of dead specimens	Total
98.81.1	*Pleuropoma beryllina*	32	3	35
	Pleuropoma fulgora	3	-	3
	Pleuropoma n. sp.	1	-	1
98.81.2	no snails seen	-	-	-
98.82.1	*Pleuropoma beryllina*	74	-	74
	Pleuropoma fulgora	8	-	8
	Pleuropoma n. sp.	1	-	1
	Diastole schmeltziana	2	-	2
98.82.2	*Pleuropoma beryllina*	-	2	2
	Pleuropoma n. sp.	2	1	3
	Paropeas achatinaceum	1	-	1
98.83.1	*Pleuropoma beryllina*	89	-	89
	Pleuropoma fulgora	4	-	4
98.83.2	*Pleuropoma fulgora*	1	1	2
	Pleuropoma n. sp.	1	-	1
	Paropeas achatinaceum	-	1	1
98.84.1	*Pleuropoma beryllina*	33	-	33
	Pleuropoma fulgora	3	-	3
	Diastole schmeltziana	7	-	7
98.84.2	*Pleuropoma* n. sp.	1	-	1
98.85.1	*Pleuropoma beryllina*	152	-	152
	Pleuropoma fulgora	4	-	4
98.85.2	*Pleuropoma beryllina*	-	4	4
98.86.1	*Pleuropoma beryllina*	106	-	106
	Pleuropoma fulgora	1	-	1
98.86.2	*Pleuropoma beryllina*	2	2	4
	Paropeas achatinaceum	-	1	1
98.86.3	Veronicellidae, unidentified	1	-	1
98.87.1	*Pleuropoma beryllina*	39	-	39
	Pleuropoma fulgora	2	-	2
	Diastole schmeltziana	7	-	7
	Diastole n. sp.	7	-	7
98.87.2	*Pleuropoma fulgora*	1	1	2
98.88.1	*Pleuropoma beryllina*	57	-	57
	Pleuropoma fulgora	4	-	4
	Diastole schmeltziana	2	-	2

	Diastole n. sp.	6	-	6
98.88.2	*Orobophana musiva*	-	1	1
	Pleuropoma beryllina	1	1	2
	Pleuropoma fulgora	1	5	6
98.89.1	*Pleuropoma beryllina*	101	-	101
	Pleuropoma fulgora	-	2	2
	Diastole schmeltziana	6	-	6
	Diastole n. sp.	1	-	1
98.89.2	*Orobophana musiva*	-	2	2
	Pleuropoma beryllina	-	7	7
	Pleuropoma fulgora	-	8	8
	Diastole n. sp.	-	2	2
	Subulina octona	-	3	3
98.90.1	*Pleuropoma fulgora*	4	1	5
	Pleuropoma beryllina	50	-	50
	Subulina octona	3	-	3
98.90.2	*Pleuropoma beryllina*	-	1	1
	Pleuropoma fulgora	-	1	1
	Paropeas achatinaceum	2	-	2
	Subulina octona	4	5	9
	Allopeas clavulinum	1	-	1
98.91.1	*Pleuropoma fulgora*	6	-	6
98.91.2	*Pleuropoma fulgora*	-	7	7
	Paropeas achatinaceum	-	4	4
	Veronicellidae, unidentified	2	-	2
	Subulina octona	-	4	4
	Ouagapia gradata	1	-	1
98.92.1	*Pleuropoma fulgora*	1	-	1
98.92.2	*Pleuropoma fulgora*	-	5	5
	Paropeas achatinaceum	-	3	3
	Subulina octona	-	3	3
98.93.1	*Pleuropoma fulgora*	5	-	5
98.93.2	*Pleuropoma fulgora*	1	2	3
	Veronicellidae, unidentified	2	-	2
	Paropeas achatinaceum	-	1	1
	Subulina octona	5	11	16
98.94.1	*Pleuropoma fulgora*	-	1	1
98.94.2	*Pleuropoma fulgora*	-	1	1
	Veronicellidae, unidentified	1	-	1
	Paropeas achatinaceum	-	1	1
	Subulina octona	9	8	17
	Achatina fulica	(2)	(1)	(3)
	Ouagapia gradata	-	1	1
98.95.1	*Orobophana musiva*	16	-	16
	Pleuropoma fulgora	1	-	1
	Subulina octona	1	-	1
98.95.2	*Pleuropoma fulgora*	-	3	3
	Veronicellidae, unidentified	1	-	1
	Paropeas achatinaceum	1	2	3
	Subulina octona	8	14	22
98.96.1	*Pleuropoma fulgora*	-	1	1
98.96.2	*Pleuropoma fulgora*	-	3	3
	Allopeas clavulinum	-	1	1
	Paropeas achatinaceum	-	2	2

	Subulina octona	-	18	18
	Achatina fulica	-	(1)	(1)
98.97.1	*Paropeas achatinaceum*	-	2	2
	Succinea manuana	-	1	1
98.97.2	*Orobophana musiva*	-	8	8
	Pleuropoma fulgora	-	10	10
	Assiminea parvula	-	2	2
	Omphalotropis sp. B	-	9	9
	Paropeas achatinaceum	-	5	5
	Subulina octona	-	31	31
	Streptostele musaecola	-	2	2
	Succinea manuana	-	4	4
98.98.1	*Omphalotropis* sp. B	33	3	36
	Paropeas achatinaceum	6	1	7
	Subulina octona	1	-	1
98.98.2	*Omphalotropis* sp. B	-	19	19
	Paropeas achatinaceum	-	3	3
	Subulina octona	-	34	34
[98.99]	[*Nerita maculata*–marine	2	-	2]
	[*Nerita plicata*–marine	10	-	10]
	[*Littoraria coccinea*–marine	28	-	28]
98.100	*Melampus castaneus*	13	-	13
	[*Nerita plicata*–marine	3	-	3]
	[*Nerita polita*–marine	16	-	16]
	[*Littoraria coccinea*–marine	4	-	4]
98.101.1	*Pleuropoma fulgora*	3	-	3
	Allopeas clavulinum	6	-	6
	Paropeas achatinaceum	14	1	15
	Subulina octona	1	-	1
98.101.2	*Orobophana musiva*	-	1	1
	Pleuropoma fulgora	9	1	10
	Tralia costata	-	1	1
	Subulina octona	1	2	3
	Succinea manuana	-	5	5
	Liardetia samoensis	1	-	1
98.102.1	*Pleuropoma beryllina*	21	-	21
	Paropeas achatinaceum	1	-	1
	Subulina octona	5	-	5
98.102.2	*Pleuropoma fulgora*	3	-	3
	Paropeas achatinaceum	5	-	5
	Subulina octona	22	-	22
98.103.1	*Pleuropoma fulgora*	1	-	1
	Succinea manuana	1	-	1
98.103.2	*Pleuropoma fulgora*	3	-	3
	Pythia scarabaeus	1	-	1
	Paropeas achatinaceum	4	1	5
	Subulina octona	20	4	24
	Succinea manuana	-	1	1
98.104.1	*Pleuropoma fulgora*	2	-	2
	Paropeas achatinaceum	2	-	2
98.104.2	*Pleuropoma fulgora*	1	1	2
	Paropeas achatinaceum	2	6	8
[98.105]	[*Neritina* sp. A–freshwater	5	-	5]
98.106.1	*Succinea manuana*	-	2	2

98.106.2	*Pleuropoma fulgora*	-	2	2
	Allopeas clavulinum	-	3	3
	Succinea manuana	-	1	1
98.107.1	*Orobophana musiva*	1	-	1
	Pythia scarabaeus	2	-	2
98.107.2	*Orobophana musiva*	1	-	1
	Pythia scarabaeus	1	2	3
	Liardetia samoensis	1	-	1
98.108	*Pythia scarabaeus*	5	3	8
98.109	*Orobophana musiva*	-	7	7
	Truncatella guerinii	-	2	2
	Assiminea parvula	-	1	1
	Pythia scarabaeus	-	11	11
	Allopeas clavulinum	-	1	1
	Paropeas achatinaceum	-	1	1
	Subulina octona	-	8	8
98.110	*Melampus fasciatus*	16	2	18
	Pythia scarabaeus	5	3	8
98.111	*Orobophana musiva*	-	3	3
	Pythia scarabaeus	1	3	4
	Succinea manuana	-	1	1
98.112	*Allopeas clavulinum*	3	-	3
98.113	*Melampus fasciatus*	6	1	7
	Pythia scarabaeus	2	-	2
98.114	*Pythia scarabaeus*	1	4	5
	Paropeas achatinaceum	-	1	1
98.115	*Orobophana musiva*	2	-	2
98.116	Veronicellidae, unidentified	2	-	2
98.117.1	*Pleuropoma fulgora*	-	2	2
98.117.2	*Pleuropoma fulgora*	-	7	7
	Allopeas clavulinum	-	1	1
	Paropeas achatinaceum	1	-	1
	Subulina octona	2	2	4
98.118.1	*Pleuropoma fulgora*	-	1	1
98.118.2	*Pleuropoma fulgora*	-	1	1
	Subulina octona	2	2	4
98.119.1	*Pleuropoma fulgora*	-	1	1
98.119.2	*Pleuropoma fulgora*	-	1	1
	Paropeas achatinaceum	-	1	1
	Subulina octona	-	21	21
98.120.1	no snails seen	-	-	-
98.120.2	*Pleuropoma fulgora*	-	9	9
	Paropeas achatinaceum	-	2	2
	Subulina octona	-	5	5
98.121.1	no snails seen	-	-	-
98.121.2	*Orobophana musiva*	-	1	1
	Subulina octona	-	1	1
98.122	*Melampus castaneus*	18	-	18
	Melampus fasciatus	4	-	4
98.123.1	*Pleuropoma beryllina*	25	-	25
	Pleuropoma fulgora	1	-	1
98.123.2	*Pleuropoma fulgora*	-	3	3
98.124.1	*Pleuropoma beryllina*	44	-	44
	Paropeas achatinaceum	1	-	1

	Subulina octona	1	-	1
98.124.2	*Pleuropoma beryllina*	-	1	1
	Pleuropoma fulgora	-	2	2
	Allopeas clavulinum	-	1	1
	Paropeas achatinaceum	-	2	2
	Subulina octona	1	2	3
98.125.1	*Pleuropoma beryllina*	53	-	53
	Pleuropoma fulgora	2	-	2
	Diastole n. sp.	1	-	1
98.125.2	*Pleuropoma beryllina*	-	2	2
	Pleuropoma fulgora	1	-	1
	Allopeas clavulinum	1	1	2
98.126.1	*Pleuropoma beryllina*	40	-	40
98.126.2	*Pleuropoma beryllina*	1	1	2
	Pleuropoma fulgora	2	-	2
98.127.1	*Pleuropoma fulgora*	1	1	2
98.127.2	*Pleuropoma fulgora*	-	4	4
	Allopeas clavulinum	2	2	4
	Paropeas achatinaceum	1	1	2
	Subulina octona	1	-	1
	Succinea manuana	-	2	2
98.128.1	no snails seen	-	-	-
98.128.2	*Pleuropoma fulgora*	-	1	1
	Succinea manuana	-	1	1
98.129.1	no snails seen	-	-	-
98.129.2	*Orobophana musiva*	-	1	1
	Allopeas clavulinum	-	1	1
98.130.1	no snails seen	-	-	-
98.130.2	*Pleuropoma fulgora*	-	15	15
	Veronicellidae, unidentified	1	-	1
	Allopeas clavulinum	-	7	7
	Liardetia samoensis	-	3	3
98.131.1	*Orobophana musiva*	1	-	1
	Elasmias sp.	21	-	21
98.131.2	*Orobophana musiva*	-	6	6
	Allopeas clavulinum	1	-	1
	Paropeas achatinaceum	-	3	3
	Subulina octona	-	20	20
98.132.1	no snails seen	-	-	-
98.132.2	*Orobophana musiva*	-	4	4
	Pythia scarabaeus	1	1	2
	Subulina octona	-	6	6
98.133.1	*Succinea manuana*	2	-	2
98.133.2	*Orobophana musiva*	-	3	3
	Pleuropoma fulgora	-	2	2
	Paropeas achatinaceum	4	5	9
	Subulina octona	7	7	14
	Succinea manuana	-	20	20

APPENDIX 6. OFU: NUMBER OF SPECIMENS OF EACH SPECIES COLLECTED AT EACH SAMPLING STATION

Sample numbers are field numbers of Robert H. Cowie. "98" indicates the year (1998). The second number is the sample site. The third number indicates whether the sample was taken from vegetation ("1") or from the ground ("2"). No vegetation searches were made at stations 98.134–98.136, 98.138, and 98.147, although these samples were part of the quantitative survey. A single opportunistic, untimed sample was taken that was not part of the quantitative, timed sampling program (98.141). Numbers in parentheses indicate specimens that were recorded but not collected.

Sample #	Species	Number of live specimens	Number of dead specimens	Total
98.134	*Truncatella guerinii*	10	4	14
	Melampus castaneus	1	1	2
	Melampus fasciatus	18	1	19
	Succinea manuana	-	1	1
98.135	*Melampus fasciatus*	-	3	3
	Pythia scarabaeus	6 + (26)	4	10 + (26)
98.136	*Orobophana musiva*	-	1	1
	Pleuropoma fulgora	-	1	1
	Truncatella guerinii	15	7	22
	Melampus fasciatus	-	1	1
	Pythia scarabaeus	(57)	8	(57) + 8
	Subulina octona	-	1	1
98.137.1	*Pupisoma orcula*	-	1	1
	Succinea manuana	-	5	5
98.137.2	*Orobophana musiva*	-	29	29
	Melampus castaneus	1	-	1
	Streptostele musaecola	-	1	1
	Succinea manuana	-	11	11
98.138	*Orobophana musiva*	-	11	11
	Truncatella guerinii	1	3	4
	Melampus castaneus	2	-	2
	Melampus fasciatus	134	39	173
	Lamellaxis micra	-	2	2
	Opeas hannense	-	2	2
	Paropeas achatinaceum	-	3	3
	Subulina octona	-	4	4
	Gulella bicolor	-	1	1
	Streptostele musaecola	-	3	3
	Succinea manuana	-	10	10
98.139.1	*Diastole schmeltziana*	51	-	51
	Diastole n. sp.	9	-	9
98.139.2	*Orobophana musiva*	-	1	1
	Paropeas achatinaceum	-	1	1
	Subulina octona	-	13	13
	Diastole sp.	-	4	4
98.140.1	*Orobophana musiva*	1	-	1
	Pleuropoma fulgora	2	-	2

	Samoana thurstoni	(1)	-	(1)
	Diastole schmeltziana	24	-	24
	Diastole n. sp.	2	-	2
98.140.2	*Pleuropoma fulgora*	1	3	4
	Orobophana musiva	-	1	1
	Paropeas achatinaceum	-	3	3
	Subulina octona	7	19	26
	Streptostele musaecola	-	1	1
	Diastole sp.	-	4	4
98.141	*Bradybaena similaris*	2	-	2
98.142.1	*Diastole schmeltziana*	7	-	7
98.142.2	*Pleuropoma fulgora*	-	2	2
	Samoana thurstoni	(7)	4	(7) + 4
	Allopeas clavulinum	-	1	1
	Paropeas achatinaceum	-	1	1
	Subulina octona	-	26	26
	Diastole sp.	-	1	1
98.143.1	*Eua zebrina*	10 + (78)	-	10 + 78
98.143.2	*Orobophana musiva*	-	2	2
	Eua zebrina	-	2	2
	Paropeas achatinaceum	2	-	2
	Subulina octona	35	33	68
	Ouagapia gradata	-	4	4
	Succinea manuana	-	1	1
98.144.1	no snails seen	-	-	-
98.144.2	*Orobophana musiva*	-	1	1
	Allopeas clavulinum	-	2	2
	Paropeas achatinaceum	-	2	2
	Subulina octona	4	29	33
	Gulella bicolor	-	2	2
98.145.1	no snails seen	-	-	-
98.145.2	*Orobophana musiva*	-	7	7
	Pleuropoma fulgora	-	8	8
	Subulina octona	-	25	25
98.146.1	*Orobophana musiva*	-	1	1
	Subulina octona	1	3	4
98.146.2	*Orobophana musiva*	-	44	44
	Pleuropoma fulgora	-	3	3
	Paropeas achatinaceum	-	1	1
	Subulina octona	-	46	46
	Succinea manuana	-	3	3
98.147	*Orobophana musiva*	-	30	30
	Truncatella guerinii	-	1	1
	Melampus castaneus	6	13	19
	Melampus fasciatus	15	44	59
	Tralia costata	-	1	1
	Lamellidea pusilla	-	1	1
	Opeas hannense	-	1	1
	Paropeas achatinaceum	-	2	2
	Subulina octona		28	28
	Gulella bicolor	-	2	2
	Succinea manuana	-	18	18
98.148.1	*Orobophana musiva*	-	1	1
	Pleuropoma fulgora	-	1	1

	Subulina octona	1	1	2
98.148.2	*Orobophana musiva*	-	2	2
	Pleuropoma fulgora	-	16	16
	Paropeas achatinaceum	-	4	4
	Subulina octona	-	2	2
	Succinea manuana	-	28	28
	Liardetia samoensis	-	1	1
98.149.1	no snails seen	-	-	-
98.149.2	*Orobophana musiva*	-	12	12
	Assiminea parvula	-	1	1
	Pythia scarabaeus	-	2	2
	Allopeas clavulinum	-	2	2
	Subulina octona	4	24	28
	Succinea manuana	-	2	2
98.150.1	*Elasmias* sp.	11	-	11
98.150.2	*Orobophana musiva*	-	20	20
	Pleuropoma fulgora	-	2	2
	Assiminea parvula	-	1	1
	Omphalotropis sp.	-	1	1
	Elasmias sp.	1	1	2
	Paropeas achatinaceum	1	6	7
	Lamellaxis micra	-	11	11
	Subulina octona	2	68	70
	Liardetia samoensis	-	2	2
98.151.1	*Orobophana musiva*	3	1	4
	Subulina octona	-	2	2
98.151.2	*Orobophana musiva*	-	1	1
	Pleuropoma fulgora	-	2	2
	Pythia scarabaeus	-	1	1
	Lamellaxis micra	-	1	1
	Subulina octona	9	3	12
	Succinea manuana	-	1	1

APPENDIX 7. DETAILS OF INCIDENTAL OBSERVATIONS OF LIVE PARTULIDS

None of these specimens was collected. In some instances, these observations were at particular stations of the regular, quantitative survey, but were not part of the quantitative, timed searches and so are included here as incidental observations.

TUTUILA

Sauma/Tiatauala ridge. 3 March 1998. Below station 98.1. *Eua zebrina* (dead shells), *Samoana conica* (1 dead shell).

Alava ridge. 5 March 1998. Along ridge trail approx. 30 m east from the "gazebo", which is just east of the radio tower. On *Freycinetia* in very mossy area. Not much canopy. *Eua zebrina* (1 adult).

Alava ridge. 5 March 1998. Approx. 100 m farther east from above site, along ridge. Elevation 465 m. On *Freycinetia*. *Eua zebrina* (1 juvenile).

Alava ridge. 5 March 1998. Approx. 30 m farther east from above site, along ridge. Not on *Freycinetia*. *Eua zebrina* (1 juvenile).

Alava ridge. 5 March 1998. Approx. half way between radio tower and top of Vatia powerline Trail. On *Freycinetia*. *Eua zebrina* (2 adults, 1 subadult).

Alava ridge. 5 March 1998. Approx 50 m farther east from above site, along ridge.On bird's nest fern. *Eua zebrina* (2 juveniles).

Alava ridge. 5 March 1998. Approx. 50 m farther east from above site, along ridge. Elevation 420 m. *Eua zebrina* (3 half-grown juveniles).

Alava ridge. 5 March 1998. Approx. 5 m farther east from above site, along ridge trail. *Eua zebrina* (1 subadult, 1 juvenile).

Alava ridge. 5 March 1998. Approx 150 m west of top of Vatia powerline Trail, approx. 10 m west of station 98.18. Elevation 402 m. Flagged blue and yellow. *Samoana conica* (2 adults).

Alava ridge. 5 March 1998. Approx 20 m farther east from station 98.18, along ridge. Elevation 395 m. On *Freycinetia*. *Eua zebrina* (2 adults), *Samoana abbreviata* (1 adult).

Maugaloa ridge. 5 March 1998. Approx. 15 m east of top of Vatia powerline Trail, along ridge. *Eua zebrina* (1 snail), *Samoana abbreviata* (1 snail).

Maugaloa ridge. 5 March 1998. Approx. 100 m east of first major peak east of the top of the Vatia powerline Trail, in dip along ridge trail. Elevation 375 m. *Eua zebrina* (1 adult), *Samoana abbreviata* (1 adult).

Maugaloa ridge. 5 March 1998. Approx. 30 m farther along ridge trail from above site, still in dip. Elevation 375 m. On ti. *Samoana abbreviata* (1 adult).

Maugaloa ridge. 5 March 1998. Approx. 10 m farther along ridge trail from above site, still in dip. Elevation 375 m. *Eua zebrina* (1 snail), *Samoana abbreviata* (1 subadult).

Faiga ridge. 9 March 1998. Approx. 20 m down the trail from station 98.42. Elevation 263 m. *Eua zebrina* (1 adult).

Faiga ridge. 9 March 1998. At station 98.42. *Samoana conica* (1 adult, in addition to those recorded in the regular sample at this station).

Faiga ridge. 9 March 1998. Between stations 98.41 and 98.42. Elevation 275 m. *Eua zebrina* (1 adult), *Samoana conica* (1 adult, 1 juvenile).

Faiga ridge. 9 March 1998. Approx. 10 m down along the trail from the above site; above station 98.42. *Eua zebrina* (3 adults, 1 half-grown), *Samoana conica* (2 adults, 2 half-grown).

Faiga ridge. 9 March 1998. Just above station 98.42. Elevation 274 m. *Eua zebrina* (1 adult), *Samoana conica* (4 adults, 8 half-grown).

Faiga ridge. 9 March 1998. Below station 98.42. Elevation 236 m. *Samoana conica* (1 half-grown).

Pagatatua ridge. 10 March 1998. Between stations 98.48 and 98.49. Elevation 106 m. *Eua zebrina* (1 adult, 1 half-grown, 1 small juvenile).

Vatia powerline trail. 11 March 1998. At station 98.55. *Samoana conica* (1 half-grown, in addition to those recorded in the regular sample at this station).

Vatia powerline trail. 11 March 1998. Approx. 20 m along down trail from station 98.55. *Eua zebrina* (2 adults), *Samoana conica* (1 half-grown).

Vatia powerline trail. 11 March 1998. Approx. 5 m along down trail from above site. *Eua zebrina* (2 adults), *Samoana conica* (2 adults).

Vatia powerline trail. 11 March 1998. Approx. 10 m along down trail from above site. Elevation 335 m. *Eua zebrina* (1 adult).

Vatia powerline trail. 11 March 1998. Approx. 5 m along down trail from above site. *Eua zebrina* (3 adults, 1 subadult).

Vatia powerline trail. 11 March 1998. Approx. 10 m along down trail from above site. *Eua zebrina* (1 adult).

Vatia powerline trail. 11 March 1998. Approx. 10 m along down trail from above site. Elevation still 335 m. *Eua zebrina* (3 adults), *Samoana conica* (2 half-grown).

Vatia powerline trail. 11 March 1998. Approx. 20 m along down trail from above site. Elevation 328 m. *Samoana conica* (3 adults, 1 half-grown, 1 small juvenile).

Vatia powerline trail. 11 March 1998. Farther along down trail from above site. Elevation 308 m. *Eua zebrina* (1 adult), *Samoana conica* (4 adults).

Vatia powerline trail. 11 March 1998. Approx. 5 m along down trail from above site. *Samoana conica* (6 adults).

Vatia powerline trail. 11 March 1998. Approx. 10 m along down trail from above site. *Samoana conica* (1 adult).

Vatia powerline trail. 11 March 1998. Farther along down trail from above site. Elevation 294 m. Above station 98.56. *Samoana conica* (1 half-grown).

Alava ridge. 12 March 1998. At station 98.62. *Eua zebrina* (2 snails, in addition to those recorded in the regular sample at this station).

Alava ridge. 12 March 1998. At station 98.63. *Eua zebrina* (4 adults, in addition to those recorded in the regular sample at this station).

Alava ridge. 12 March 1998. At station 98.64. *Eua zebrina* (1 adult, in addition to those recorded in the regular sample at this station), *Samoana conica* (1 subadult, in addition to those recorded in the regular sample at this station).

Faiga ridge. 12 March 1998. Approx. 44 m down in elevation from top of trail on Alava ridge. Elevation 428 m. *Eua zebrina* (2 adults).

Faiga ridge. 12 March 1998. Farther down along trail from above site. Elevation 419 m. *Samoana conica* (1 adult).

Faiga ridge. 12 March 1998. Farther down along trail from above site. Elevation 415 m. *Samoana conica* (2 adults).

Faiga ridge. 12 March 1998. Farther down along trail from above site. Elevation 377 m. *Samoana conica* (1 adult).

Faiga ridge. 12 March 1998. Farther down along trail from above site. Elevation 369 m. *Samoana conica* (1 half-grown, 1 small juvenile).

Toa ridge. 12 March 1998. Approx. 44 m down in elevation from top of trail on Alava ridge. Elevation 446 m. *Samoana conica* (1 adult, 1 subadult).

Toa ridge. 12 March 1998. Farther down along trail from above site. Elevation 428 m. *Samoana conica* (1 subadult, 1 half-grown).

Toa ridge. 12 March 1998. Farther down along trail from above site. Elevation 413 m. *Samoana conica* (1 subadult).

Maatulua ridge. 13 March 1998. Approx. 10 m up along trail from station 98.70. *Samoana conica* (1 adult, 2 subadults).

Maatulua ridge. 13 March 1998. Farther up along trail from above site. Elevation 392 m. *Samoana conica* (1 adult, 1 half-grown).

Maatulua ridge. 13 March 1998. At station 98.71. *Samoana conica* (1 half-grown, in addition to those recorded in the regular sample at this station).

Leemo ridge. 6 October 1998. At station 98.152. *Eua zebrina* (1 adult, in addition to those recorded in the regular sample at this station).

Leemo ridge. 6 October 1998. Between stations 98.153 and 98.154. Elevation 235 m. *Eua zebrina* (1 adult).

Toa ridge. 8 October 1998. Between stations 98.169 and 98.170. Elevation 246 m. *Eua zebrina* (3 juveniles), *Samoana conica* (1 adult, 1 subadult).

Toa ridge. 8 October 1998. Cutting to the east of the ridge line. Lot of fern. Elevation 249 m. *Samoana conica* (3 adults).

Toa ridge. 8 October 1998. Elevation 134 m. *Eua zebrina* (2 adults).

Toa ridge. 8 October 1998. Between stations 98.169 and 98.170. Elevation 205 m. *Eua zebrina* (1 juvenile).

Toa ridge. 8 October 1998. Between stations 98.169 and 98.170. Elevation 243 m. *Eua zebrina* (2 adults).

Toa ridge. 8 October 1998. Between stations 98.169 and 98.170. Elevation 273 m. *Eua zebrina* (1 adult), *Samoana conica* (2 adults).

Toa ridge. 8 October 1998. Elevation 313 m. *Eua zebrina* (3 adults).

Toa ridge. 8 October 1998. Elevation 423 m. *Samoana abbreviata* (1 subadult).

Faiga-powerline contour. 9 October 1998. Survey route 11A (Figure 2). Various locations approximately along the 215 m [c. 700 ft] elevation contour. *Eua zebrina* (32 adults, 8 subadults, 5 juveniles), *Samoana conica* (11 adults, 11 subadults, 14 juveniles).

Amalau coast. 10 October 1998. Survey route 14A (Figure 2). Various locations between shore and 42 m elevation. *Eua zebrina* (133 adults, 3 juveniles).

Vaiola stream. 10 October 1998. Survey route 13A (Figure 2). Elevation 192 m. *Eua zebrina* (2 adults).

Powerline-Matavalu ridge. 12 October 1998. Survey route 11B (Figure 2). Various locations approximately along the 290 m [c. 950 ft] elevation contour, from the Vatia powerline trail to the ridge and valley immediately west of Matavalu ridge. *Eua zebrina* (93 adults, 4 subadults, 16 juveniles), *Samoana conica* (16 adults, 2 subadults, 11 juveniles).

Matavalu ridge-Faatafe stream. 12 October 1998. Survey route 11B (Figure 2). Elevation 237 m. *Samoana conica* (1 adult).

Sauma/Tiatauala ridge-Matavalu ridge. 13 October 1998. Survey route 13B (Figure 2). Various locations approximately between the 260 m [850 ft] and 305 m [1000 ft] contours, from Sauma/Tiatauala ridge to the ridge immediately east of Matavalu ridge, between Tofu and Faatafe streams. *Eua zebrina* (15 adults, 1 subadult), *Samoana conica* (1 adult, 1 subadult).

Polauta ridge. 14 October 1998. Survey route 12A. (Figure 2). On Polauta ridge itself. Elevation 113 m. *Eua zebrina* (2 adults).

Polauta ridge. 14 October 1998. Survey route 12A. (Figure 2). On Polauta ridge itself. Elevation 135 m. *Eua zebrina* (1 adult).

Polauta ridge. 14 October 1998. Survey route 12A. (Figure 2). On Polauta ridge itself. Elevation 155 m. *Eua zebrina* (1 adult).

Polauta ridge. 14 October 1998. Survey route 12A. (Figure 2). On Polauta ridge itself. Elevation 1198 m. *Samoana abbreviata* (1 subadult).

Polauta/Siuono saddle. 14 October 1998. Survey route 12A (Figure 2). West side of saddle between saddle and shore. Elevation 56 m. *Eua zebrina* (8 adults). Note: altimeter readings much too high.

Polauta/Siuono saddle. 14 October 1998. Survey route 12A (Figure 2). West side of saddle between saddle and shore. Elevation 48 m. *Eua zebrina* (5 adults). Note: altimeter readings much too high.

Fagatuitui cove trail. 15 October 1998. Down west side of ridge from elevation 68 m on ridge. Elevation 39 m. *Eua zebrina* (1 adult).

Fagatuitui cove trail. 15 October 1998. Down west side of ridge from elevation 68 m on ridge. Elevation 29 m. *Eua zebrina* (1 adult).

Fagatuitui cove trail. 15 October 1998. Elevation 297 m. *Samoana conica* (1 adult, 1 juvenile).

Fagatuitui cove trail. 15 October 1998. Elevation 313 m. *Eua zebrina* (1 adult), *Samoana conica* (1 adult).

Fagatuitui cove trail. 15 October 1998. Elevation 318 m. *Samoana conica* (1 adult).

OFU

Tumu mountain. 8 May 1998. At station 98.140. On *Faradaya* and *Hibiscus*. *Samoana thurstoni* (2 adults, 1 subadult, in addition to the single individual recorded in the regular sample at this station). Note: The total of four *S. thurstoni* found at this station resulted from 3 hr searching by five people over the general area.

Tumu mountain trail. 8 May 1998. At station 98.142. *Samoana thurstoni* (1 adult, in addition to those recorded in the regular sample at this station).

APPENDIX 8. DETAILS OF INCIDENTAL OBSERVATIONS OF SPECIES OTHER THAN PARTULIDS

None of these specimens was collected. In some instances, these observations were at particular stations of the regular, quantitative survey, but were not part of the quantitative, timed searches and so are included here as incidental observations.

TUTUILA

Sauma/Tiatauala ridge. 3 March 1998. Below station 98.1. *Achatina fulica* (many dead shells), *Euglandina rosea* (many dead shells).

Lalofutu Point trail. 4 March 1998. Along trail between stations 98.12 and 98.13. Elevation from 170 m to 207 m. *Achatina fulica* (quite a few large live snails, many dead), *Euglandina rosea* (many dead shells), *Gonaxis kibweziensis* (dead shells).

Alava ridge. 5 March 1998. At radio tower. *Achatina fulica* (many live).

Alava ridge. 5 March 1998. Between radio tower and top of Vatia powerline trail. *Achatina fulica* (sporadic dead shells, a few live snails).

Alava ridge. 5 March 1998. At top of Vatia powerline trail. In white ginger. *Achatina fulica* (common), *Vaginulus plebeius* (common).

Maugaloa ridge. 5 March 1998. To the east of station 98.23 but before reaching the next peak along the ridge to the east. Elevation 432 m. *Euglandina rosea* (one live adult).

Olo ridge. 6 March 1998. On roadside at start of trail up the ridge. Elevation 87 m. *Achatina fulica* (live).

Olo ridge. 6 March 1998. A few meters up the trail from the road. Elevation 118 m. *Laevicaulis alte* (1 slug).

Olo ridge. 6 March 1998. Along trail from 118 m to 199 m elevation. *Euglandina rosea* (sporadic empty shells).

Olo ridge. 6 March 1998. Elevation199 m. *Vaginulus plebeius* (2 slugs).

Olo ridge. 6 March 1998. From 234 m to top of trail on Maugaloa ridge. *Euglandina rosea* (sporadic).

Plantation ridge trail. 14 March 1998. At station 98.78. *Achatina fulica* (1 dead shell), *Gonaxis kibweziensis* (1 dead shell).

Faiga-Powerline contour. 9 October 1998. Survey route 11A (Figure 2). Various locations approximately along the 215 m [c. 700 ft] elevation contour (approx.). *Achatina fulica* (11 dead shells), *Euglandina rosea* (3 dead shells), *Gonaxis kibweziensis* (6 dead shells).

Amalau Coast. 10 October 1998. Survey route 14A (Figure 2). Various locations between shore and 42 m elevation. *Achatina fulica* (many dead shells).

Vaiola stream. 10 October 1998. Survey route 13A (Figure 2). Between road and 192 m. *Achatina fulica* (many dead shells), *Euglandina rosea* (many dead shells and live snails).

Powerline-Matavalu ridge. 12 October 1998. Survey route 11B (Figure 2). Various locations approximately along the 290 m [c. 950 ft] elevation contour, from the Vatia powerline trail to the ridge and valley immediately west of Matavalu ridge. *Gonaxis kibweziensis* (2 dead shells), *Trochomorpha apia* (5 live snails).

Matavalu ridge-Faatafe stream. 12 October 1998. Survey route 11B (Figure 2). Elevation 260 m. *Achatina fulica* (1 dead shell).

Matavalu ridge-Faatafe stream. 12 October 1998. Survey route 11B (Figure 2). Elevation 190 m. *Achatina fulica* (many), *Euglandina rosea* (many dead shells), *Gonaxis kibweziensis* (1 dead shell).

Ridge between Tofu and Faatafe streams. 13 October 1998. Survey route 13B (Figure 2). Elevation 159 m. *Euglandina rosea* (1 dead shell).

Fagatuitui cove trail. 15 October 1998. Lower half of trail. *Euglandina rosea* (many shells).

Fagatuitui cove trail. 15 October 1998. Elevation 259 m. *Achatina fulica* (1 adult).

Amalau stream. 16 October 1998. Survey route 14B (Figure 2). Between road and waterfall at station 98.188. Helicinidae, unidentified (live snails), Veronicellidae, unidentified (live slugs), *Achatina*

fulica (extremely abundant live snails), *Paropeas achatinaceum* (live snails), *Subulina octona* (abundant live snails), *Euglandina rosea* (live snails and dead shells), *Diastole schmeltziana* (live snails).

TA'Ū

Luatele Crater. 1 May 1998. On crater floor. *Achatina fulica* (3 shells, rat predated).

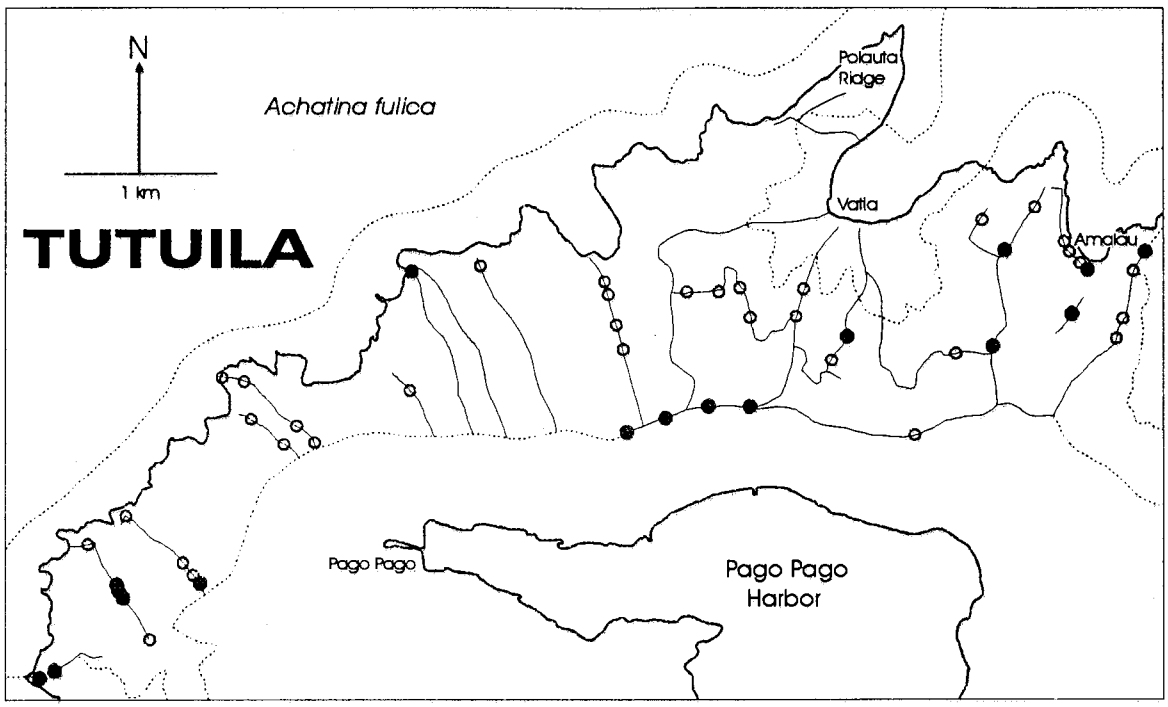
Lata Mountain trail. 1 May 1998. At station 98.96. *Achatina fulica* (1 live, 1 dead, in addition to those recorded in the regular sample at this station).

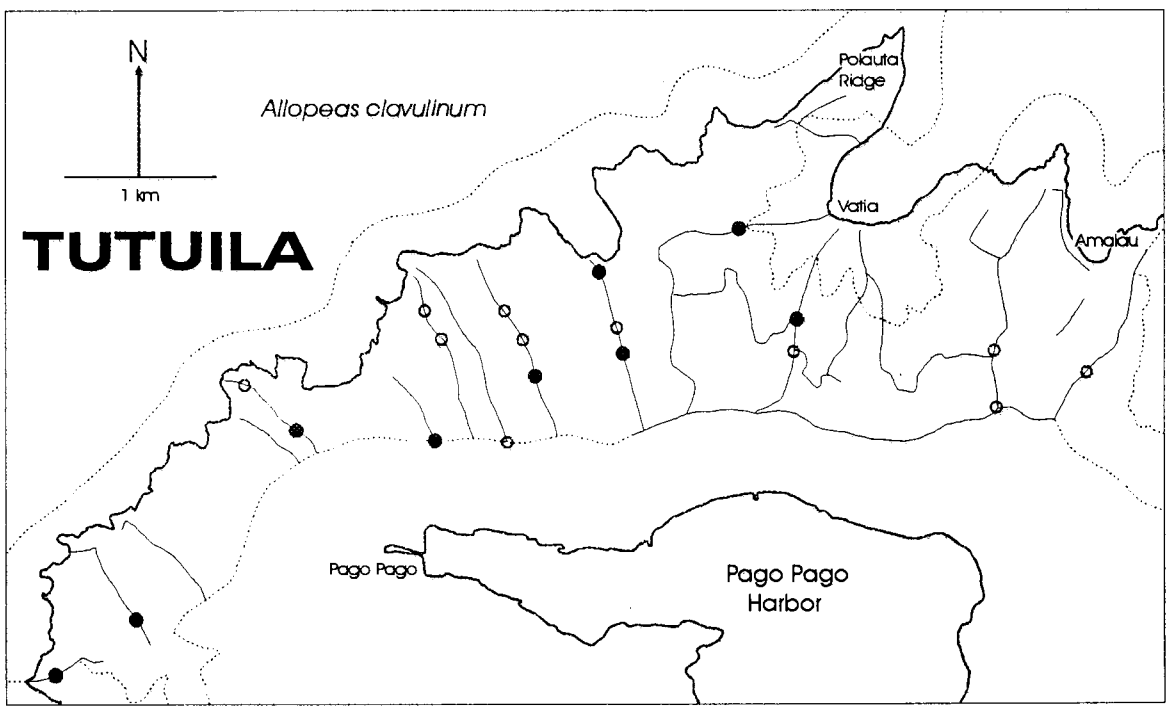
APPENDIX 9. MAPS OF SPECIES DISTRIBUTIONS

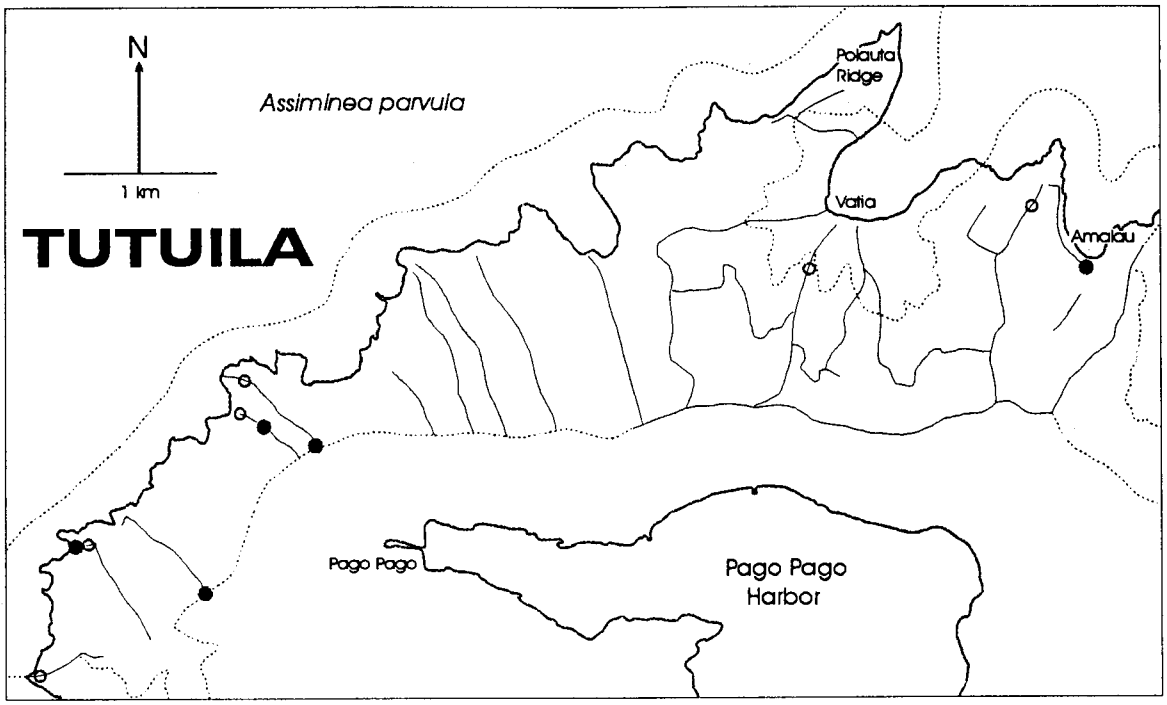
Each map shows the distribution of a single species of land snail (or slug), as recorded in the National Park of American Samoa during the 1998 survey. For species occurring on more than one island, separate maps are given for Tutuila, Ta'ū, and Ofu. The maps are arranged in sequence beginning with Tutuila, then Ta'ū, and then Ofu. Within each island, the maps are ordered alphabetically by the name of the species.

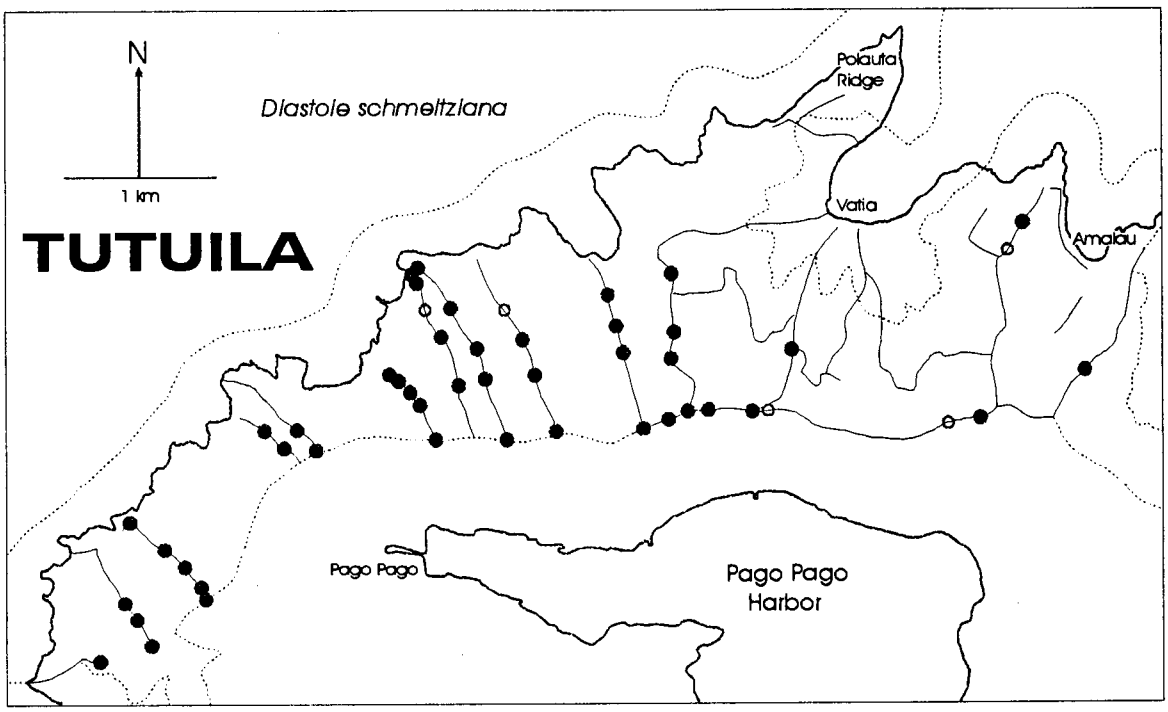
The thin solid lines represent the transects and survey routes. Details of these are given in the main body of the report: section 3.1. and Figure 2 for Tutuila, and section 3.2. and Figures 4 and 5 for Ta'ū and Ofu. The dotted lines represent the approximate boundary of the National Park.

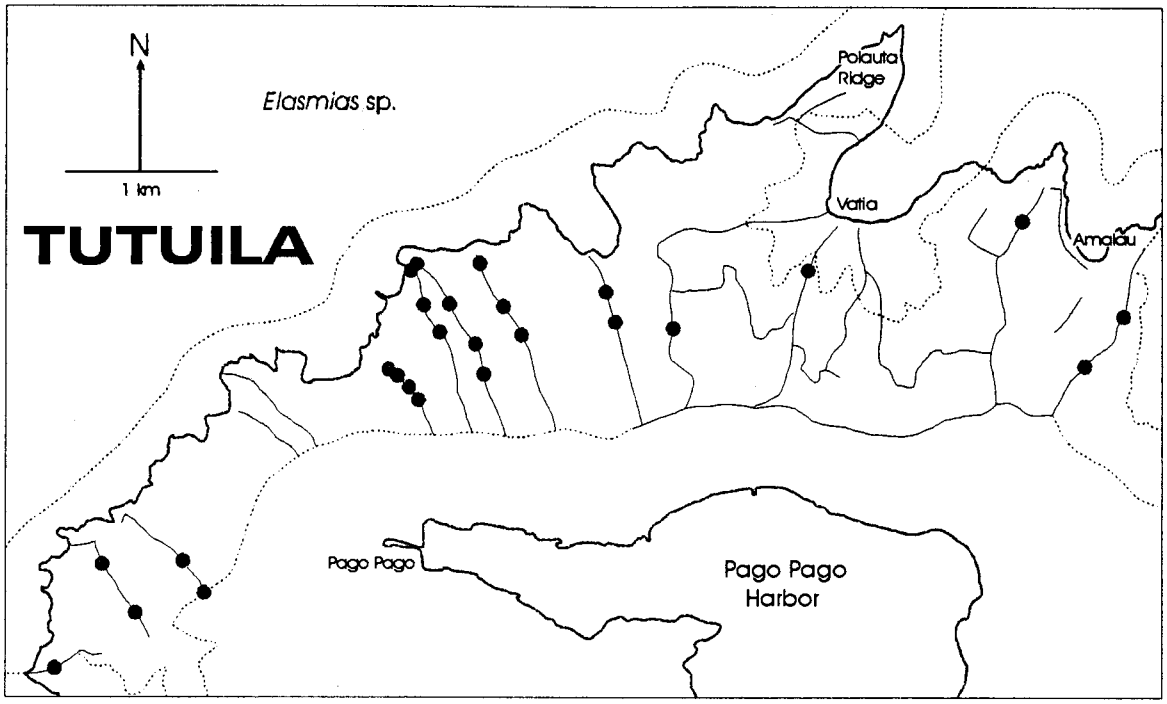
Solid circles indicate that live specimens were found. Open circles indicate that only empty shells were found. No distinction is made between the results of the main quantitative survey, incidental collection records, and other records based only on sightings not on collected samples (mostly Partulidae, but also other species). In some instances records were so close together (mostly sightings of Partulidae) that the scale of the maps does not permit them to appear distinct. For further details of all records, including numbers of individuals collected and/or seen refer to Appendices 4–8.

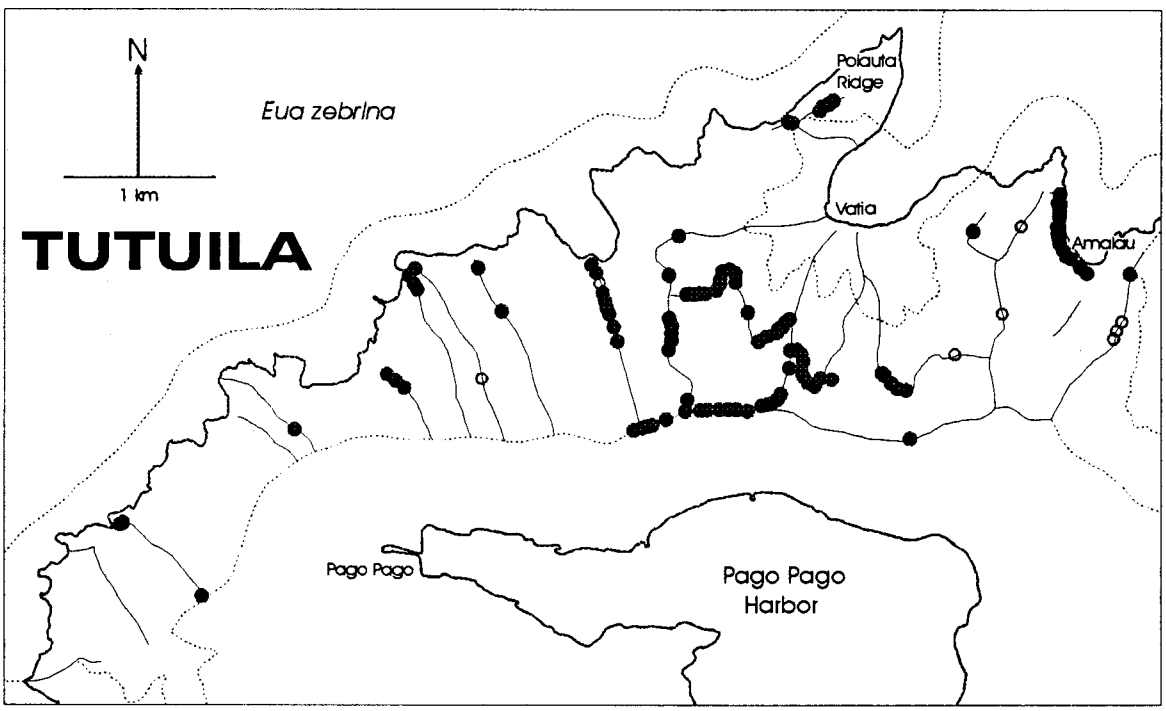

N
1 km
Achatina fulica
TUTUILA
Polauta Ridge
Vatia
Amalau
Pago Pago
Pago Pago Harbor

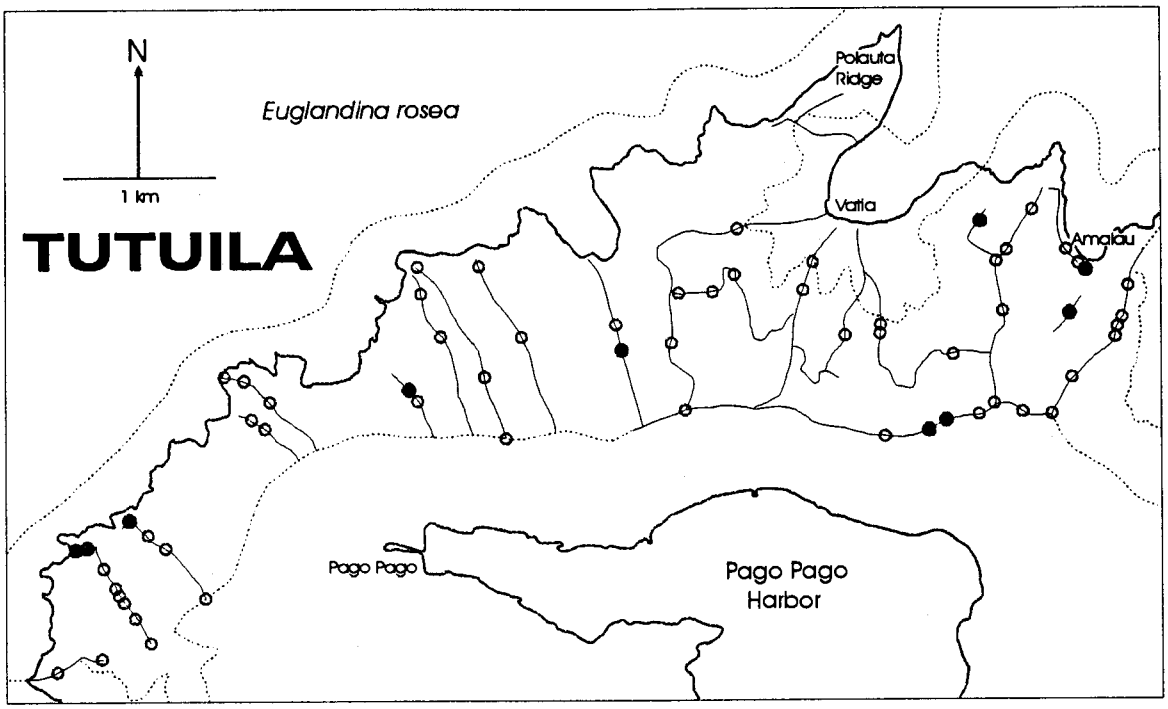

N
1 km
Allopeas clavulinum
TUTUILA
Polauta Ridge
Vatia
Amalau
Pago Pago
Pago Pago Harbor

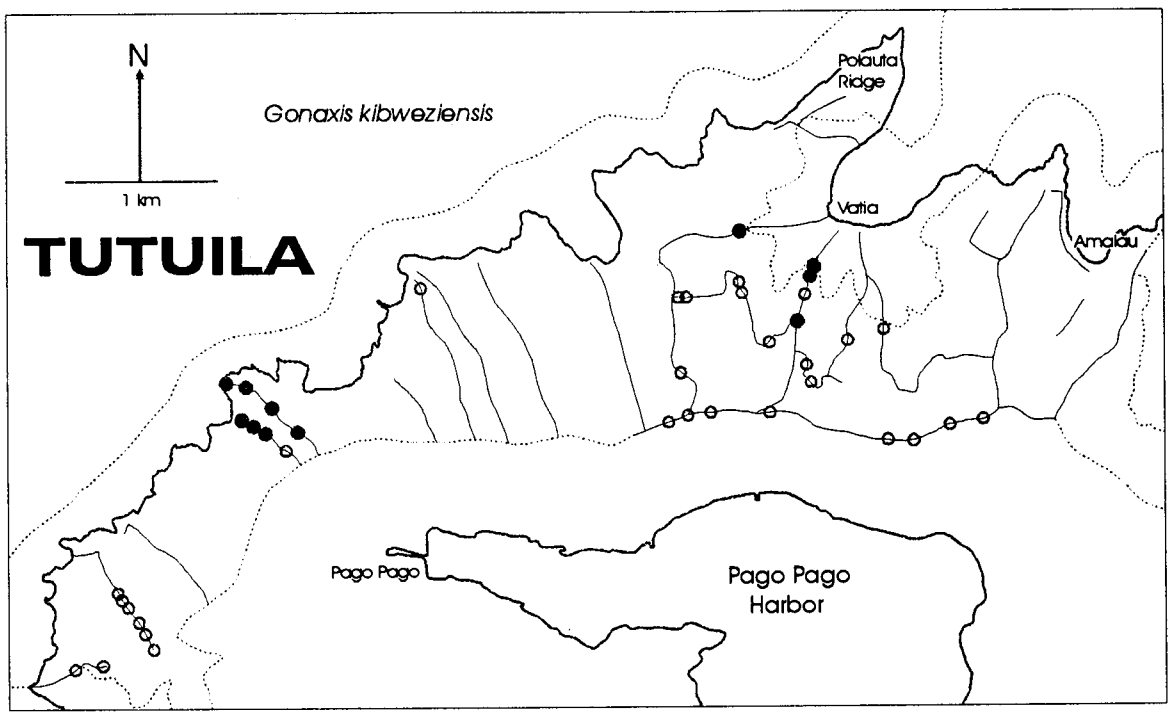

N
1 km
Assiminea parvula
TUTUILA
Polauta Ridge
Vatia
Amalau
Pago Pago
Pago Pago Harbor

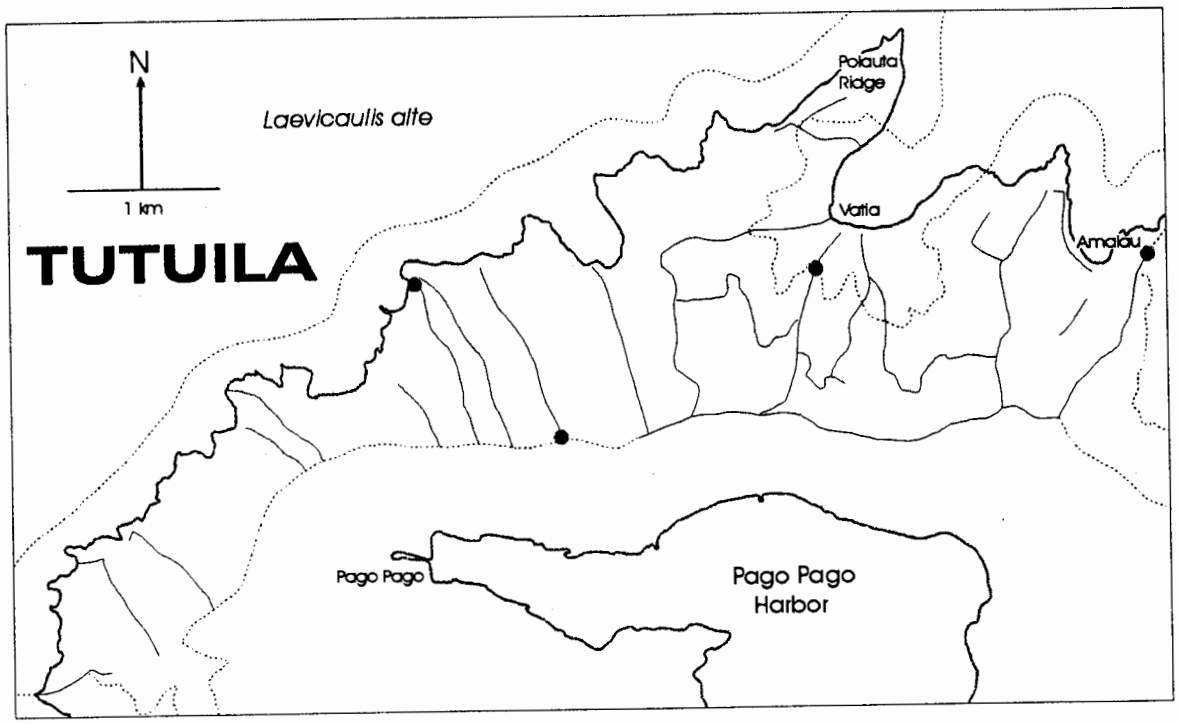

N
1 km
Diastole schmeltziana
TUTUILA
Polauta Ridge
Vatia
Amalau
Pago Pago
Pago Pago Harbor

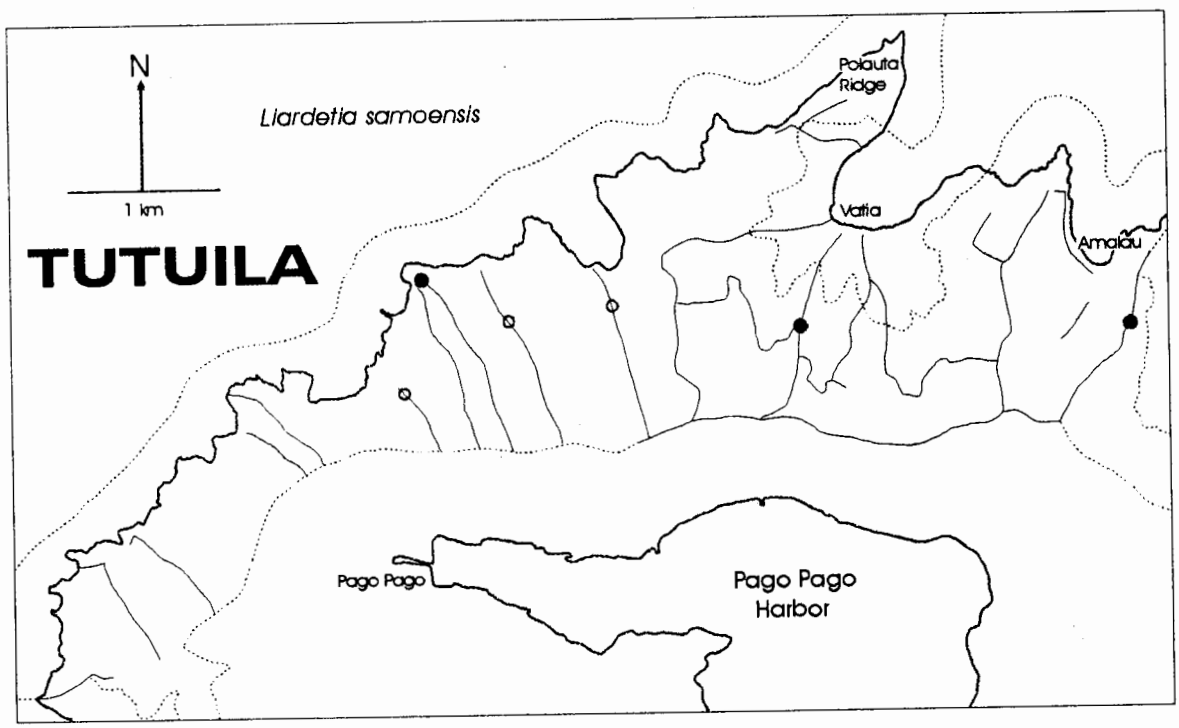

N
1 km
Elasmias sp.
TUTUILA
Polauta Ridge
Vatia
Amalau
Pago Pago
Pago Pago Harbor

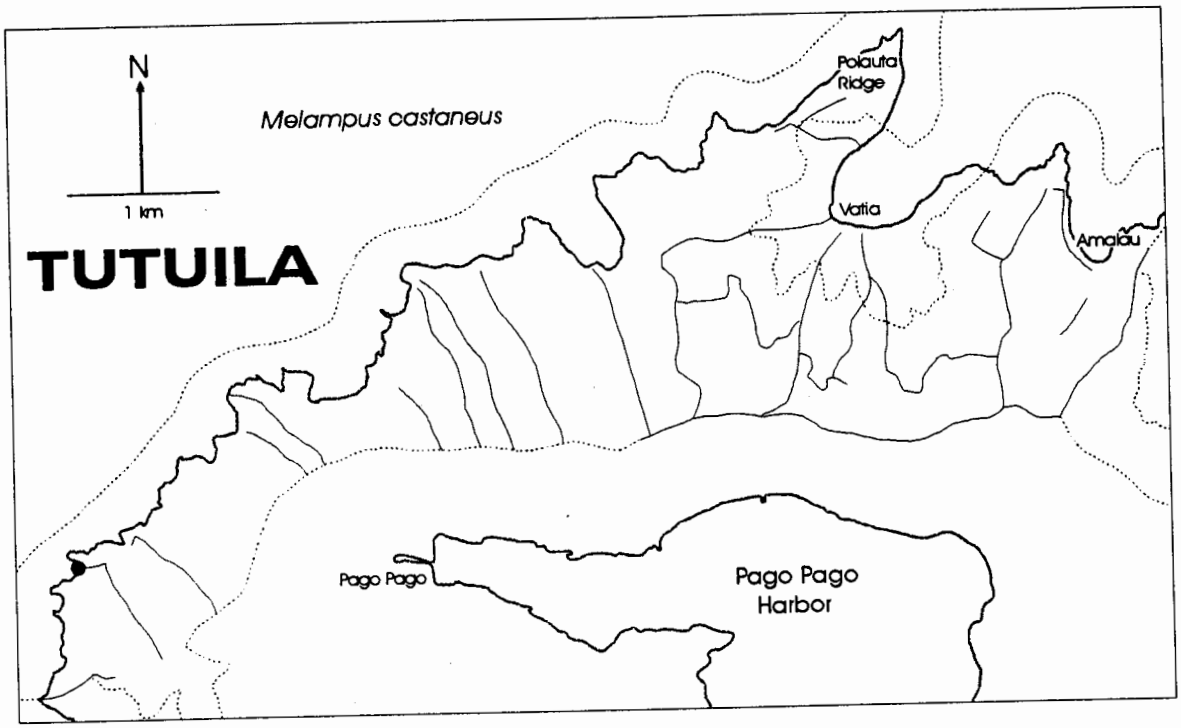

N
1 km
Eua zebrina
TUTUILA
Polauta Ridge
Vatia
Amalau
Pago Pago
Pago Pago Harbor

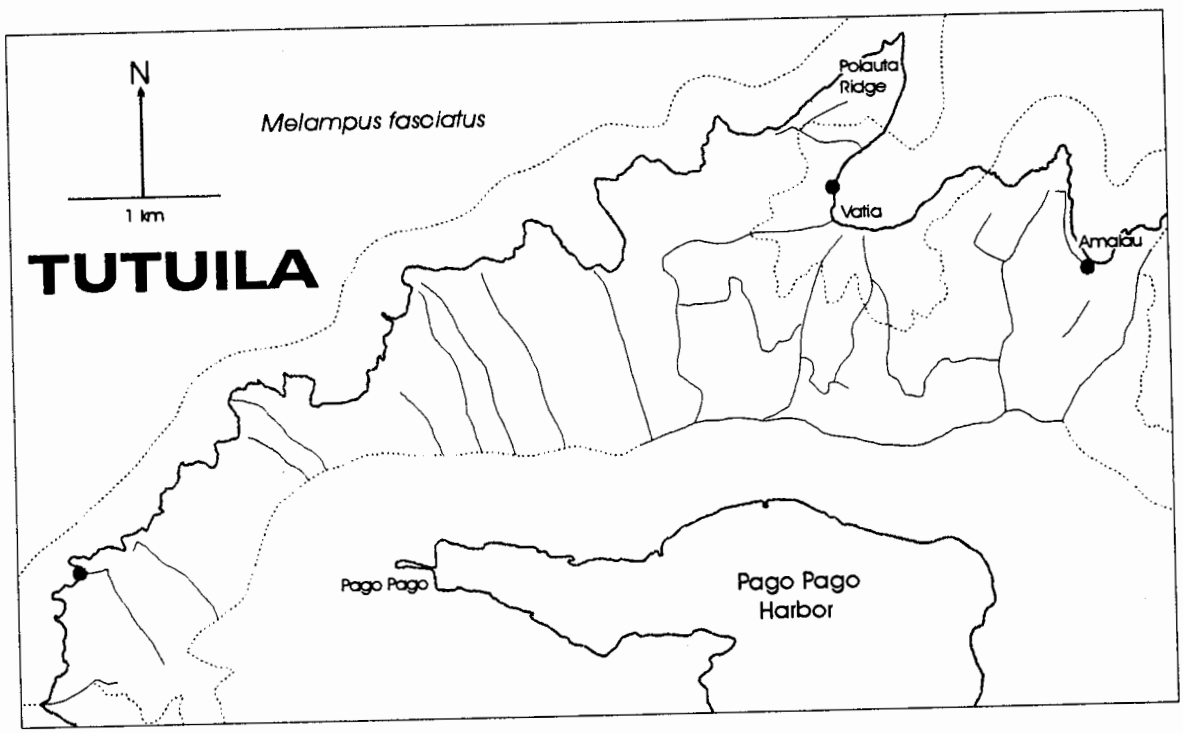

N
1 km
Euglandina rosea
TUTUILA
Polauta Ridge
Vatia
Amalau
Pago Pago
Pago Pago Harbor

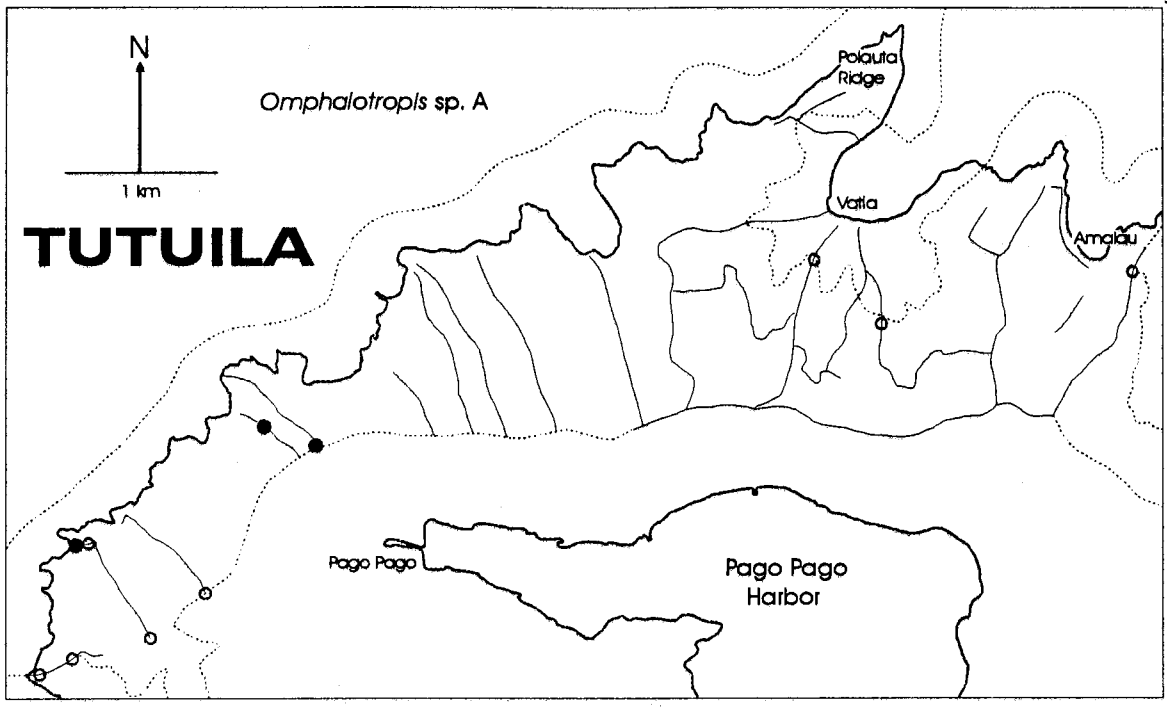

N
1 km
Gonaxis kibweziensis
TUTUILA
Polauta Ridge
Vatia
Amalau
Pago Pago
Pago Pago Harbor

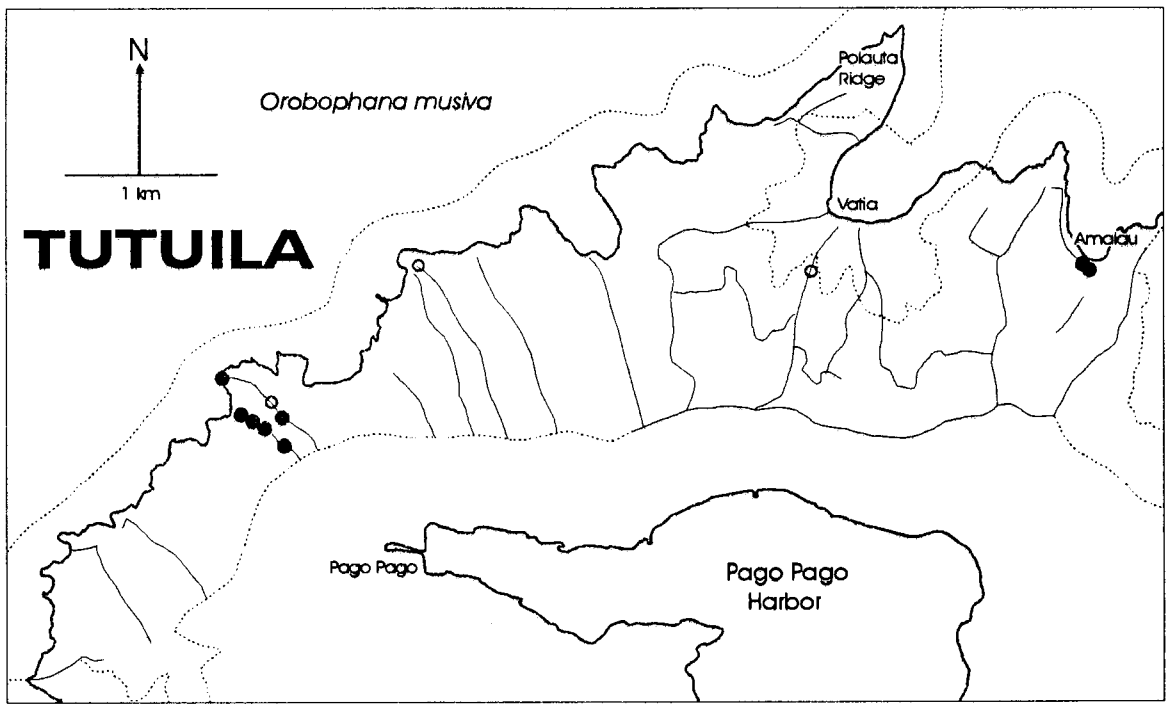

N
1 km
Laevicaulis alte
TUTUILA
Polauta Ridge
Vatia
Amalau
Pago Pago
Pago Pago Harbor

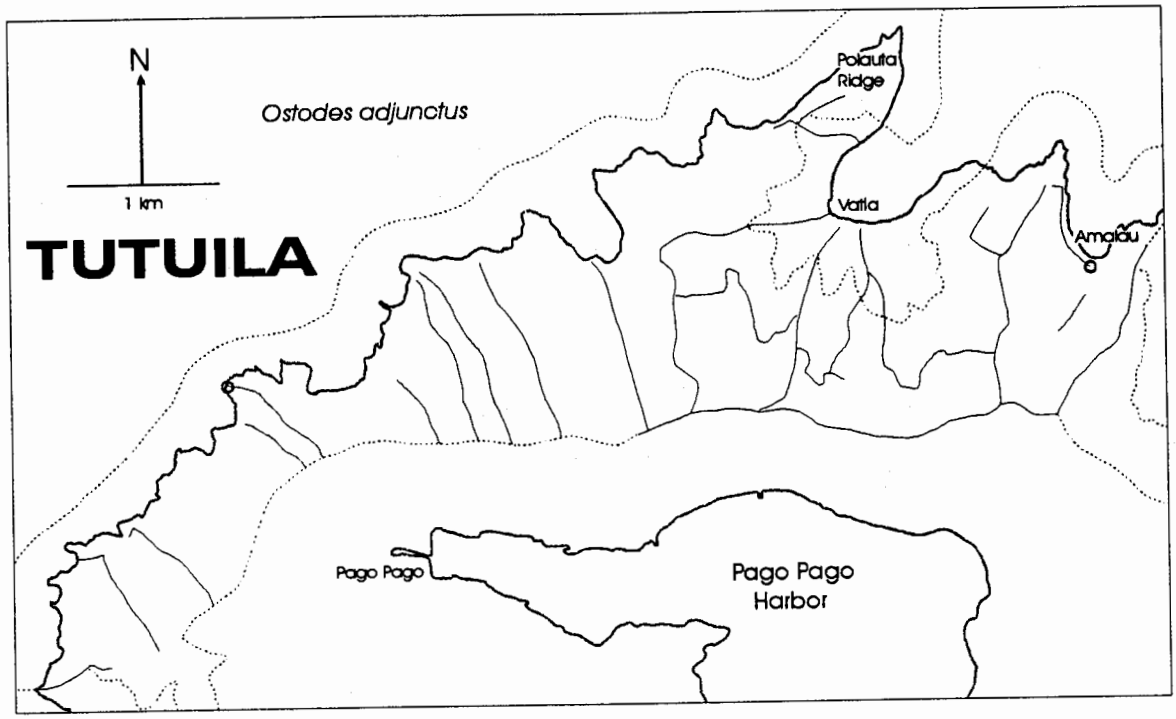

N
1 km
Liardetia samoensis
TUTUILA
Polauta Ridge
Vatia
Amalau
Pago Pago
Pago Pago Harbor

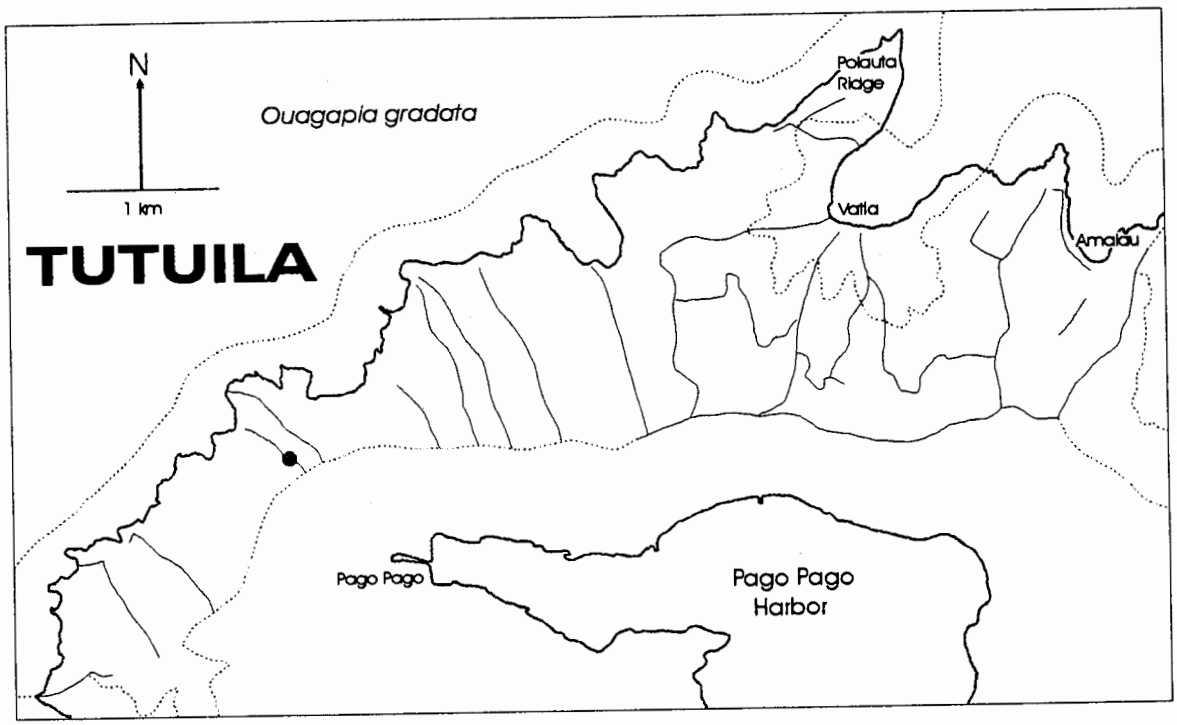

N
1 km
Melampus castaneus
TUTUILA
Polauta Ridge
Vatia
Amalau
Pago Pago
Pago Pago Harbor

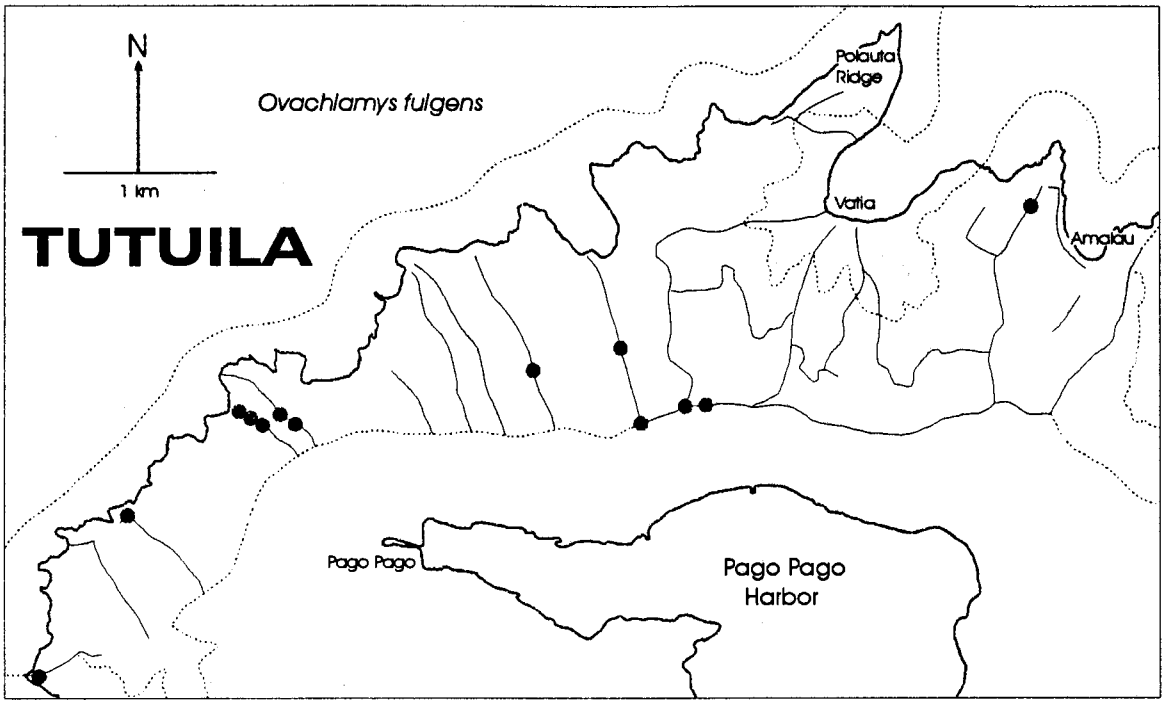

N
1 km
Melampus fasciatus
TUTUILA
Polauta Ridge
Vatia
Amalau
Pago Pago
Pago Pago Harbor

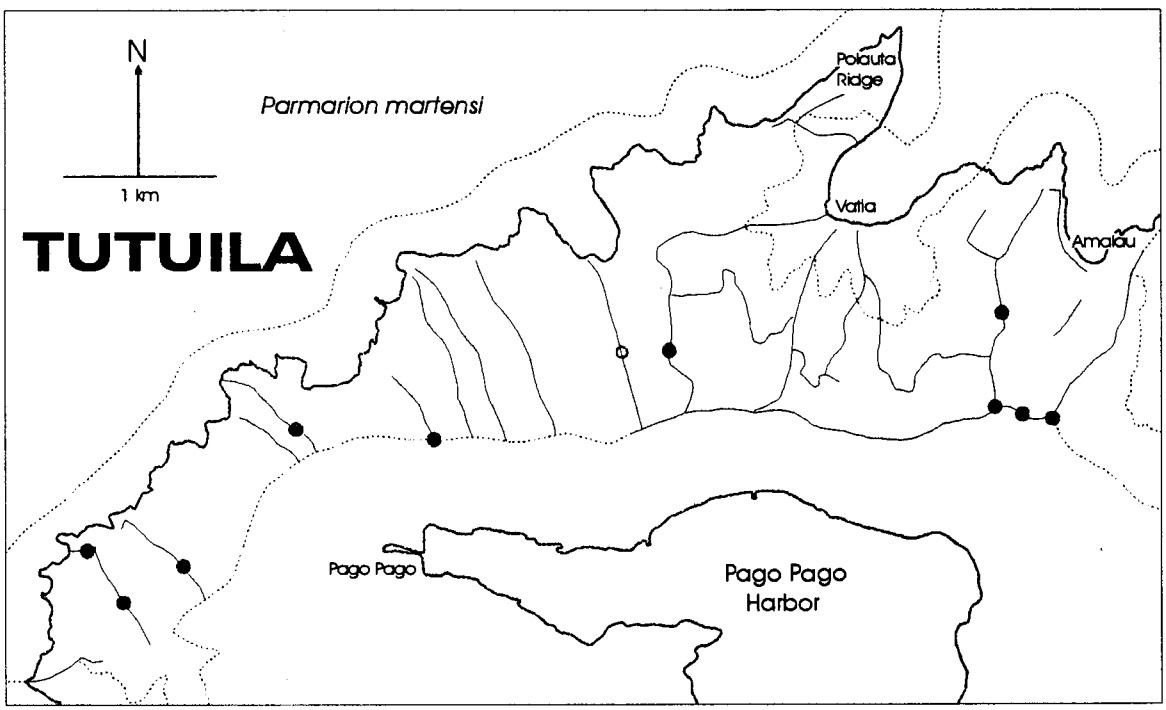

N
1 km
Omphalotropis sp. A
TUTUILA
Polauta Ridge
Vatia
Amalau
Pago Pago
Pago Pago Harbor

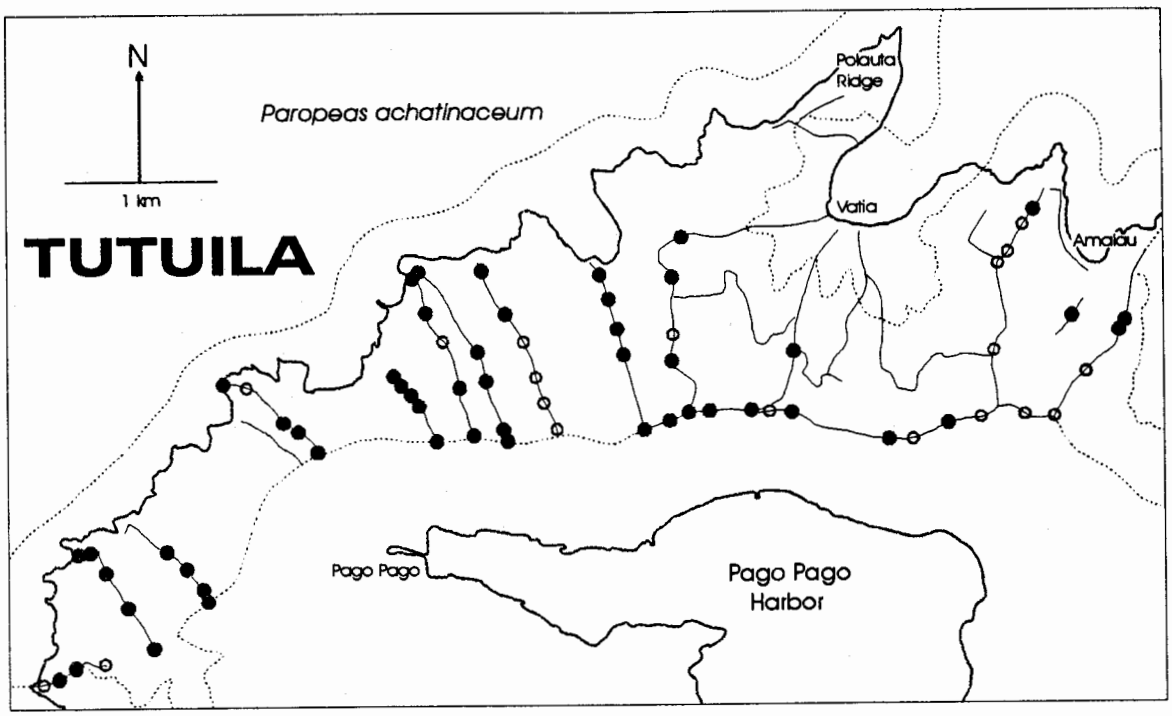

N
1 km
Orobophana musiva
TUTUILA
Polauta Ridge
Vatia
Amalau
Pago Pago
Pago Pago Harbor

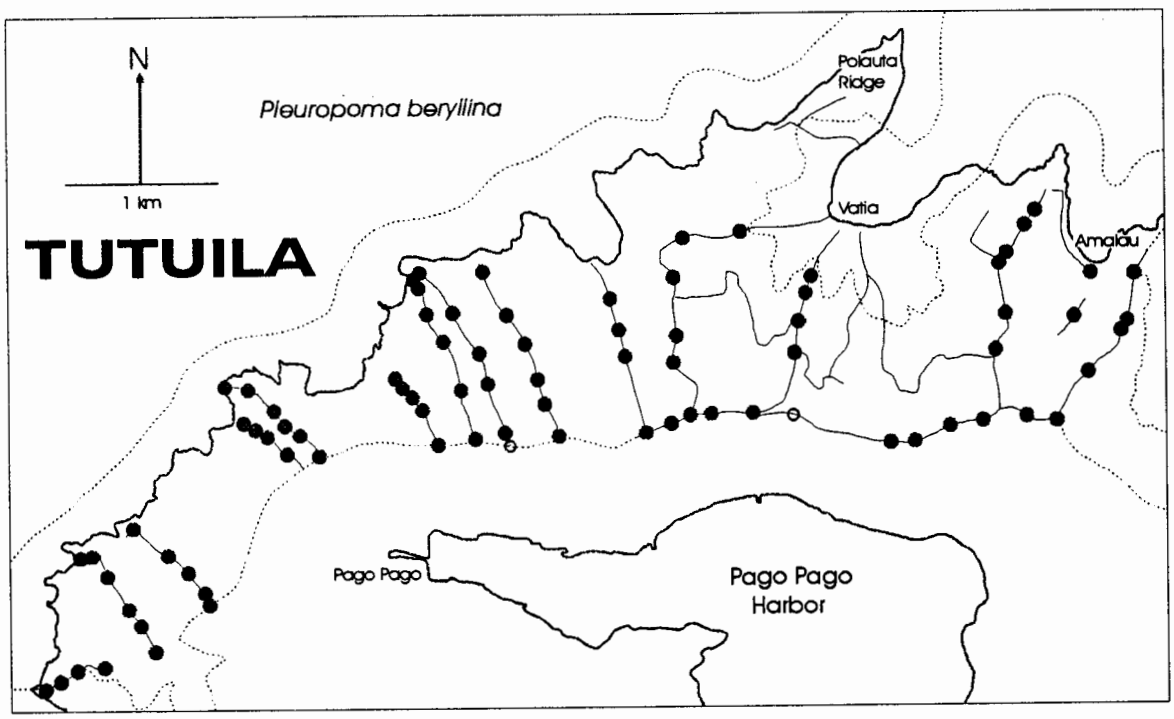

N
1 km
Ostodes adjunctus
TUTUILA
Polauta
Ridge
Vatia
Amalau
Pago Pago
Pago Pago
Harbor

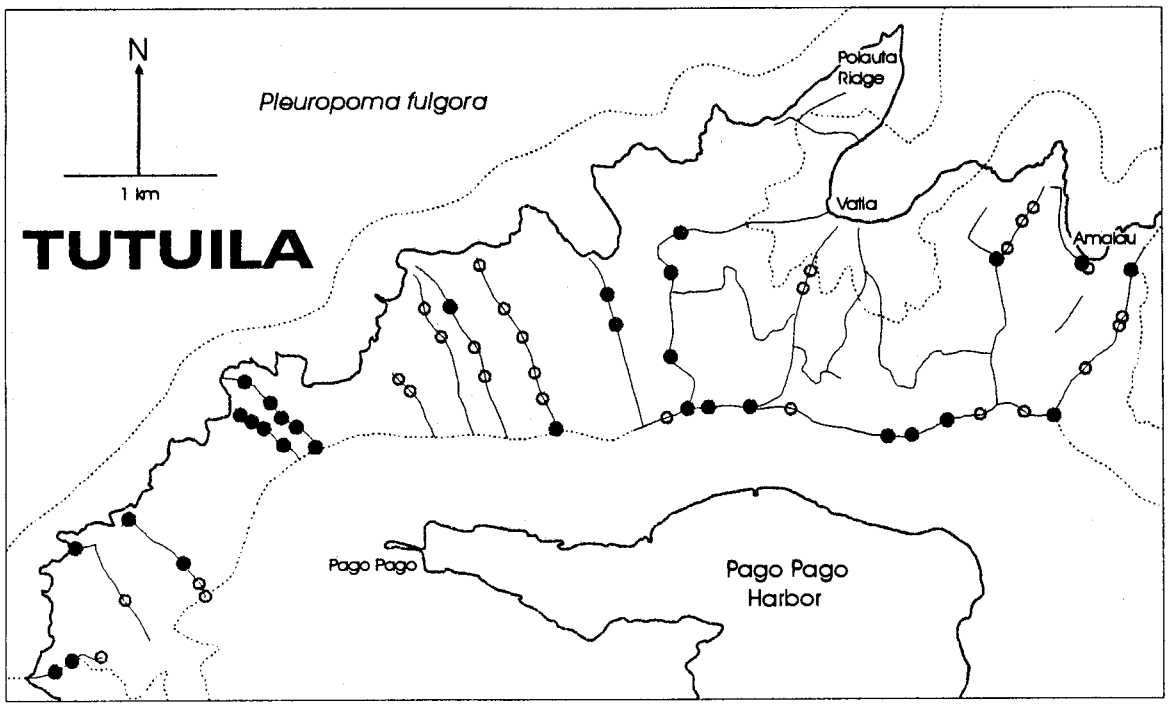

N
1 km
Ouagapia gradata
TUTUILA
Polauta
Ridge
Vatia
Amalau
Pago Pago
Pago Pago
Harbor

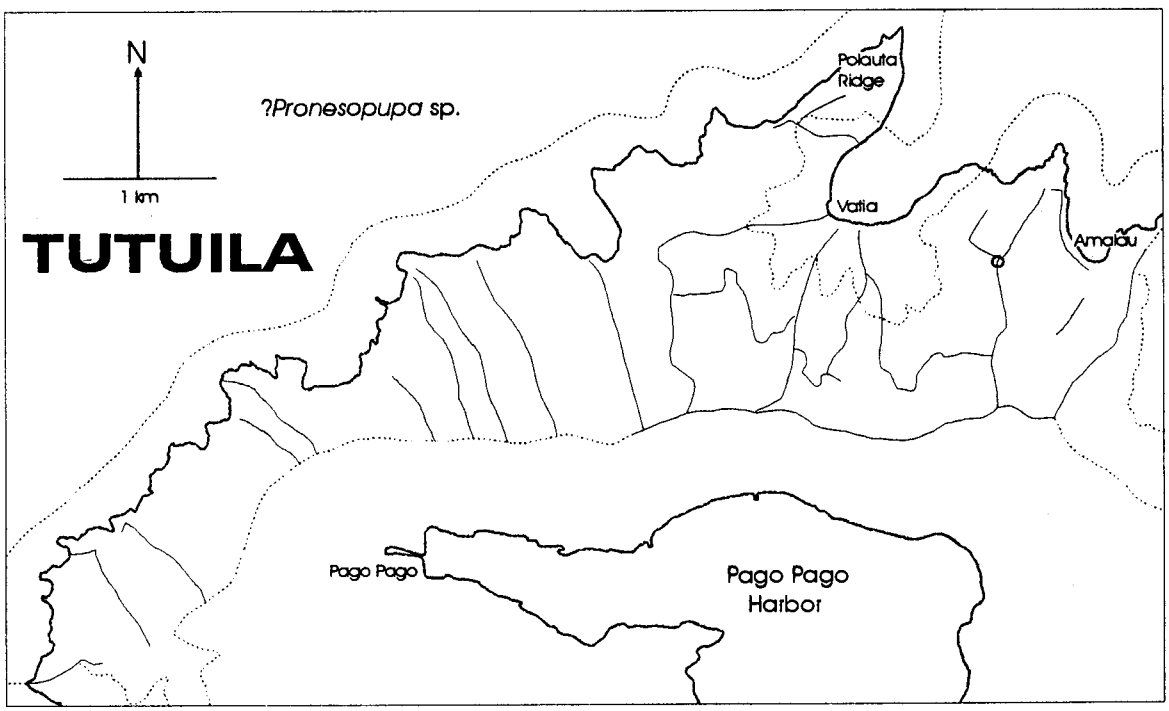

N
1 km
Ovachlamys fulgens
TUTUILA
Polauta Ridge
Vatia
Amalau
Pago Pago
Pago Pago Harbor

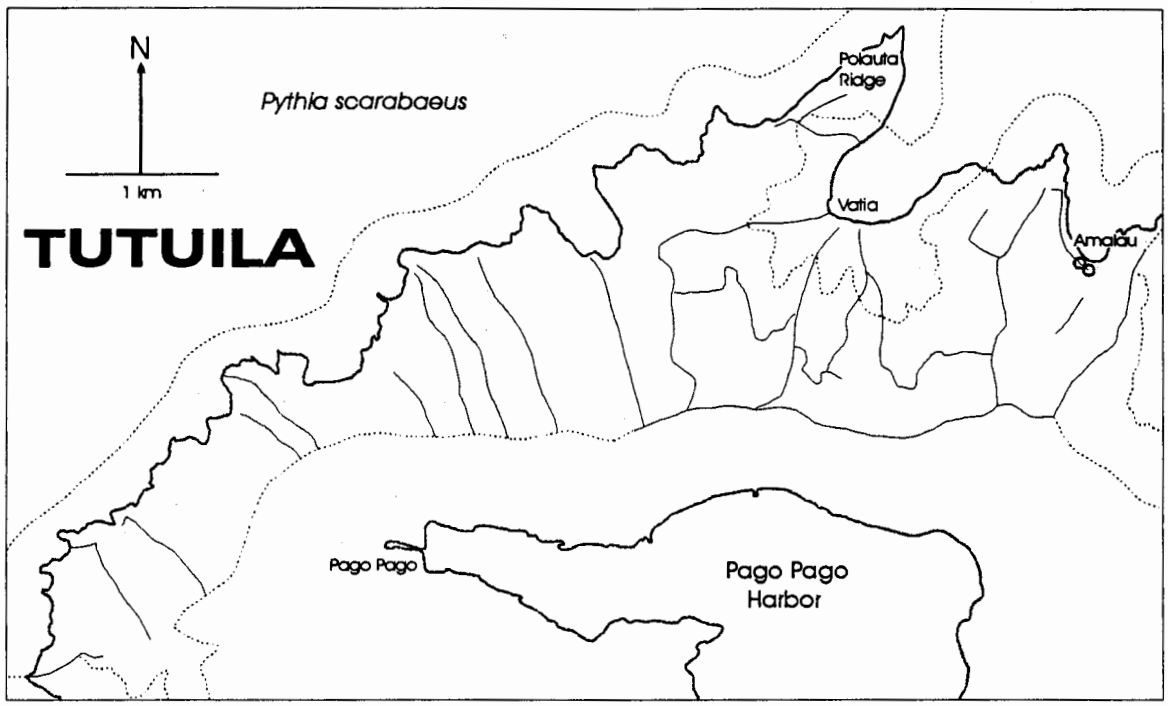

N
1 km
Parmarion martensi
TUTUILA
Polauta Ridge
Vatia
Amalau
Pago Pago
Pago Pago Harbor

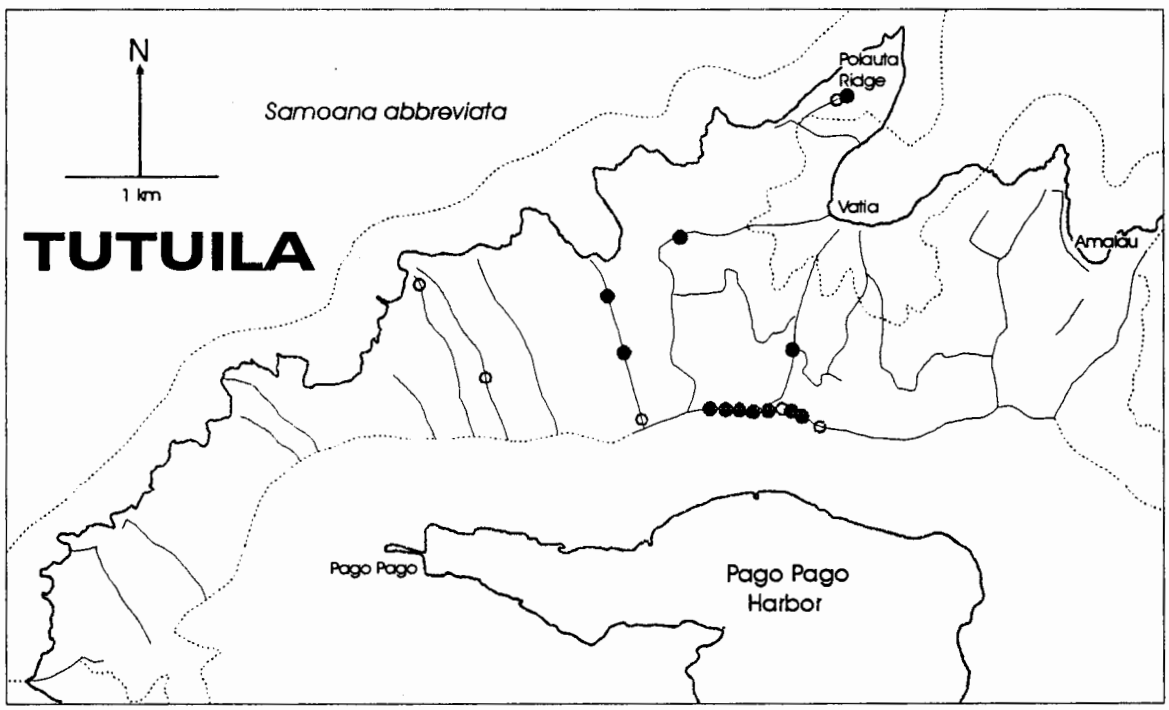

N
1 km
Paropeas achatinaceum
TUTUILA
Polauta Ridge
Vatia
Amalau
Pago Pago
Pago Pago Harbor

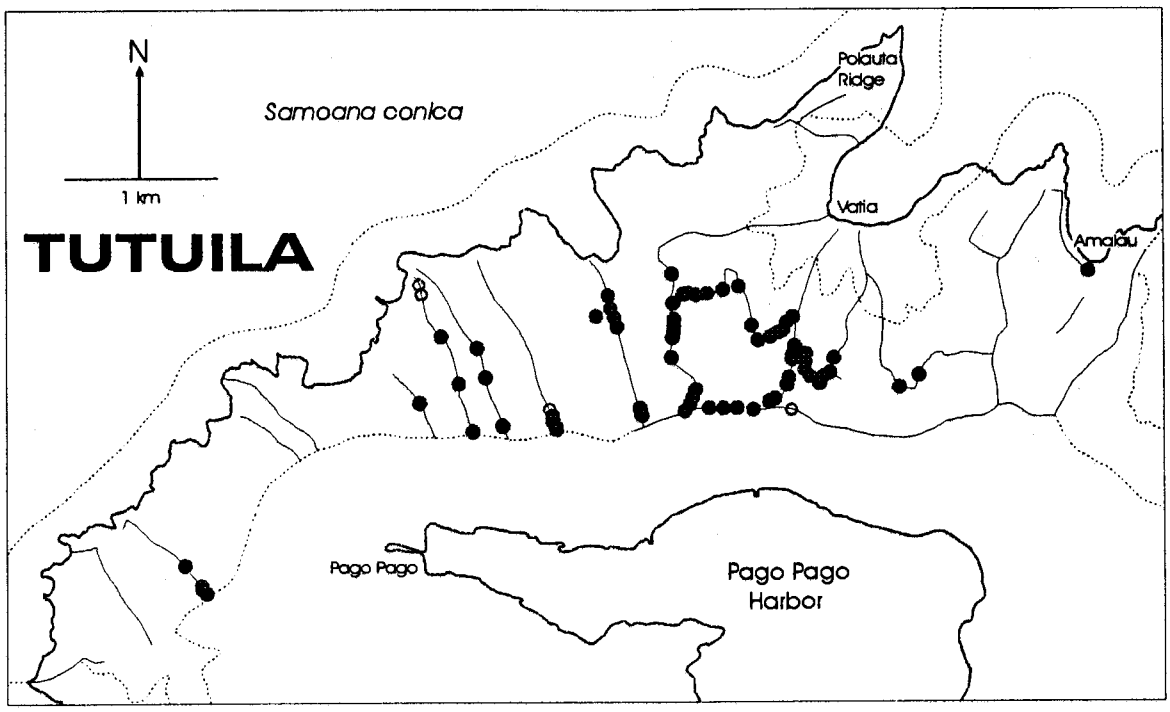

N
1 km
Pleuropoma beryllina
TUTUILA
Polauta Ridge
Vatia
Amalau
Pago Pago
Pago Pago Harbor

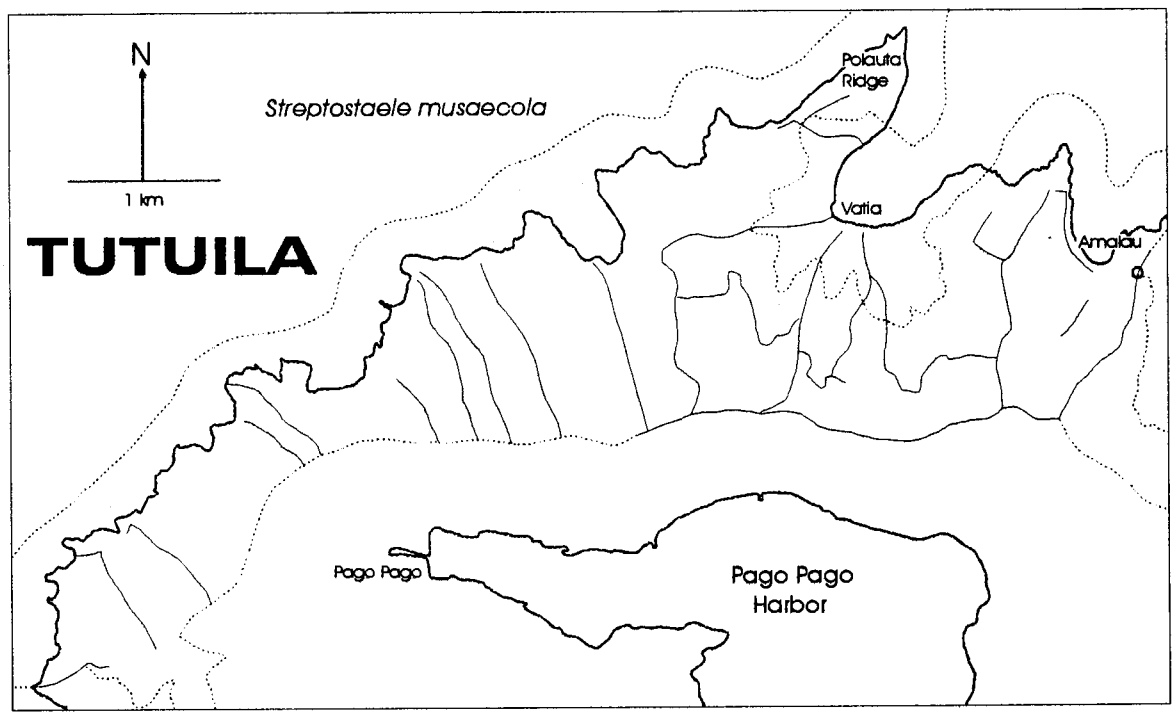

N
1 km
Pleuropoma fulgora
TUTUILA
Polauta Ridge
Vatia
Amalau
Pago Pago
Pago Pago Harbor

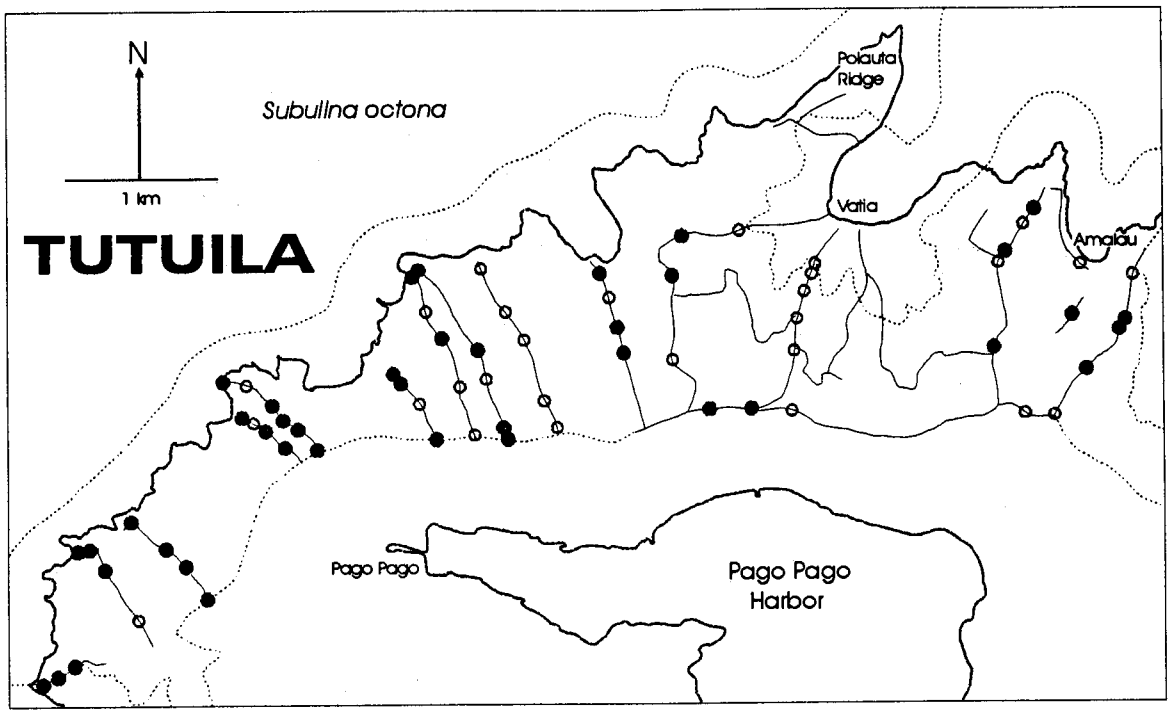

N
1 km
?Pronesopupa sp.
TUTUILA
Polauta Ridge
Vatia
Amalau
Pago Pago
Pago Pago Harbor

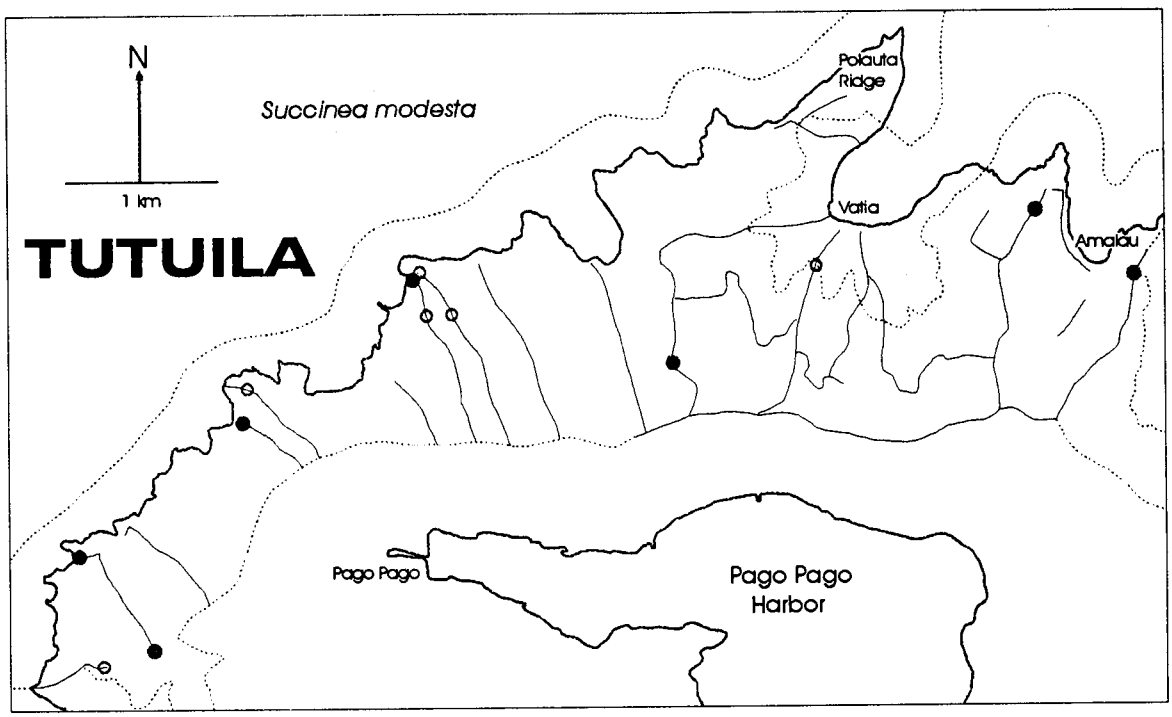

N
1 km
Pythia scarabaeus
TUTUILA
Polauta
Ridge
Vatia
Amalau
Pago Pago
Pago Pago
Harbor

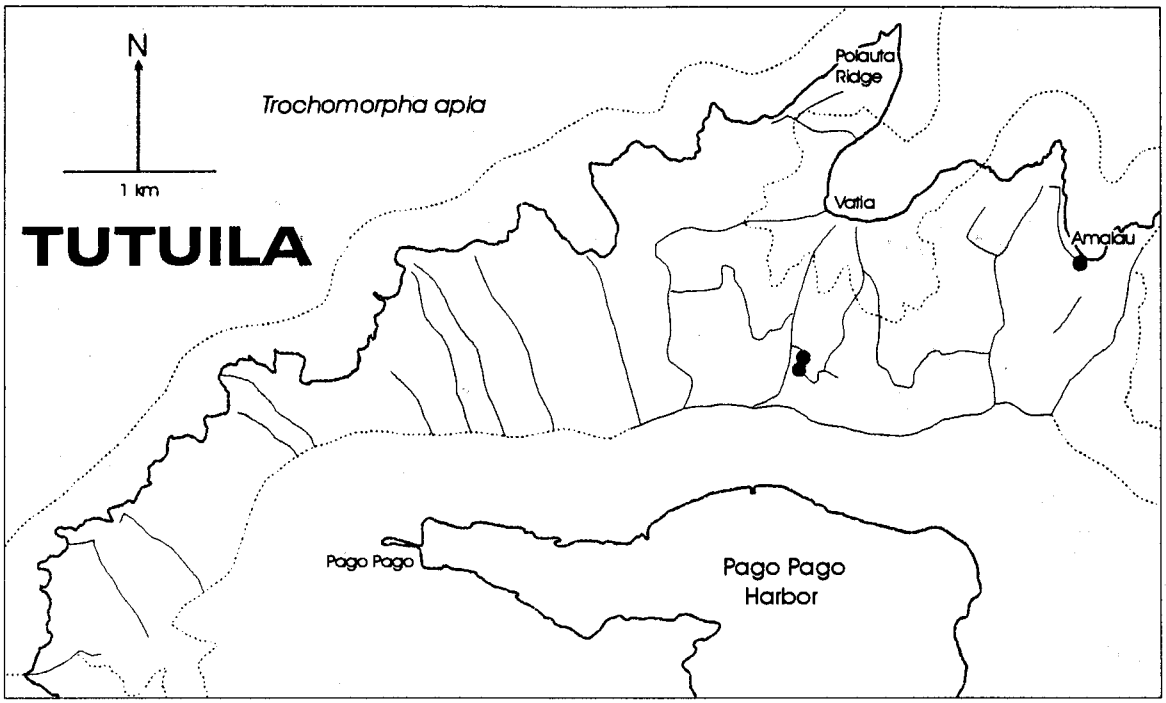

N
1 km
Samoana abbreviata
TUTUILA
Polauta
Ridge
Vatia
Amalau
Pago Pago
Pago Pago
Harbor

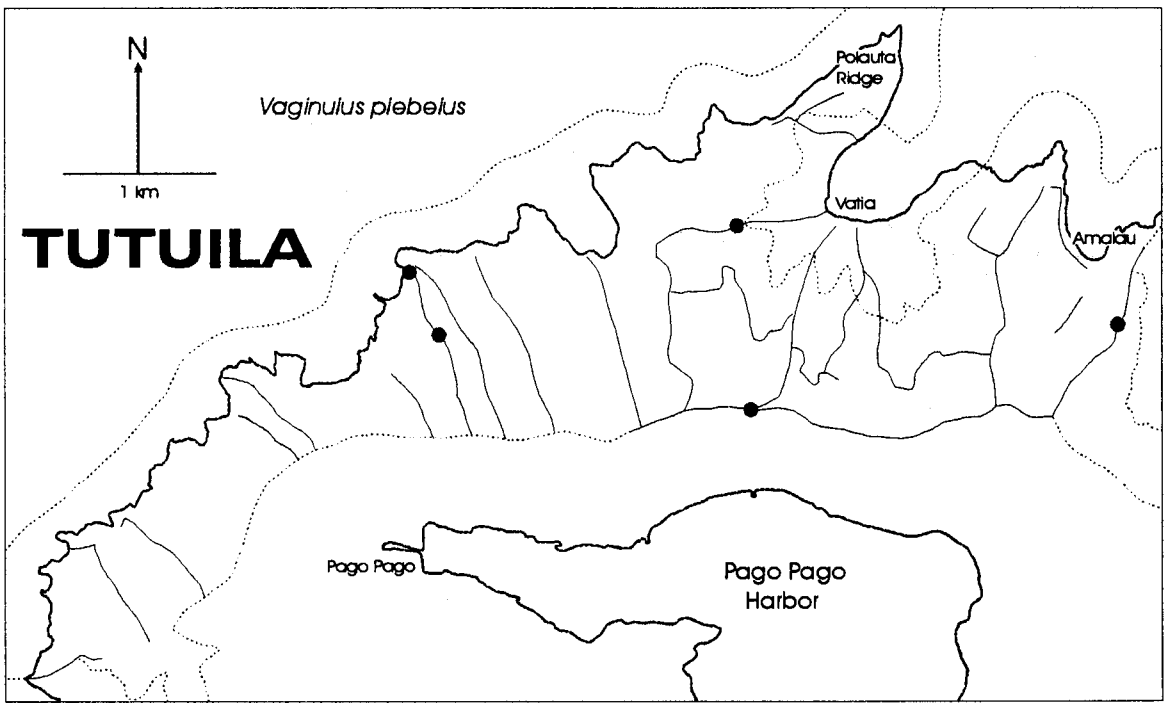

N
1 km
Samoana conica
TUTUILA
Polauta Ridge
Vatia
Amalau
Pago Pago
Pago Pago Harbor

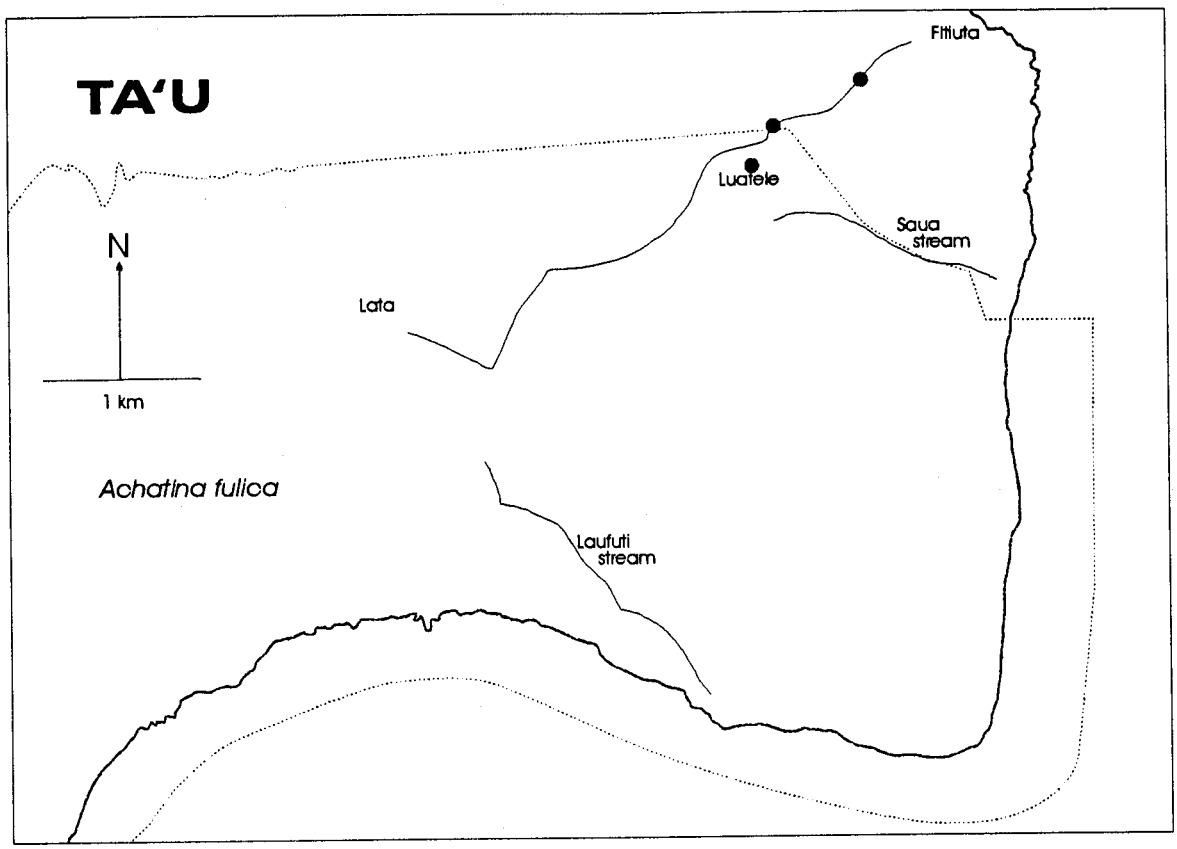

N
1 km
Streptostaele musaecola
TUTUILA
Polauta Ridge
Vatia
Amalau
Pago Pago
Pago Pago Harbor

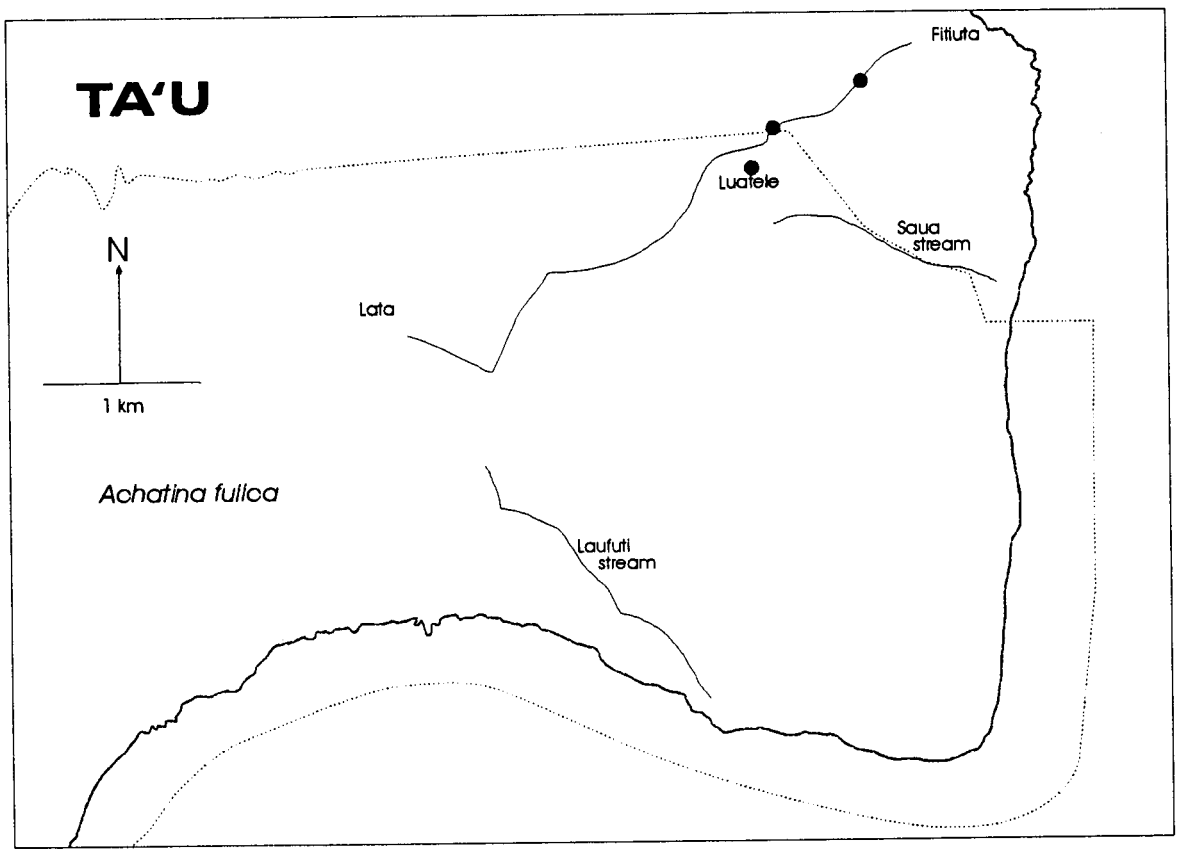

N
Subulina octona
1 km
TUTUILA
Polauta
Ridge
Vatia
Amalau
Pago Pago
Pago Pago
Harbor

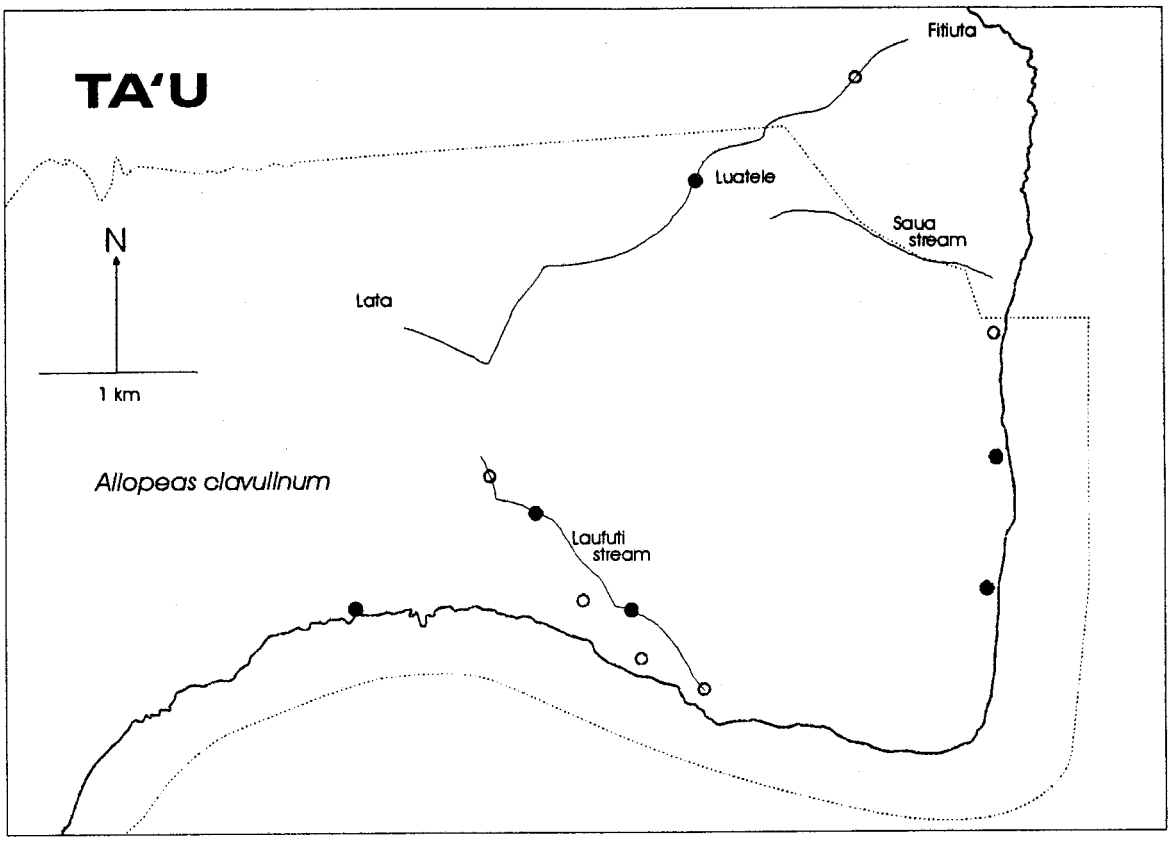

N
Succinea modesta
1 km
TUTUILA
Polauta
Ridge
Vatia
Amalau
Pago Pago
Pago Pago
Harbor

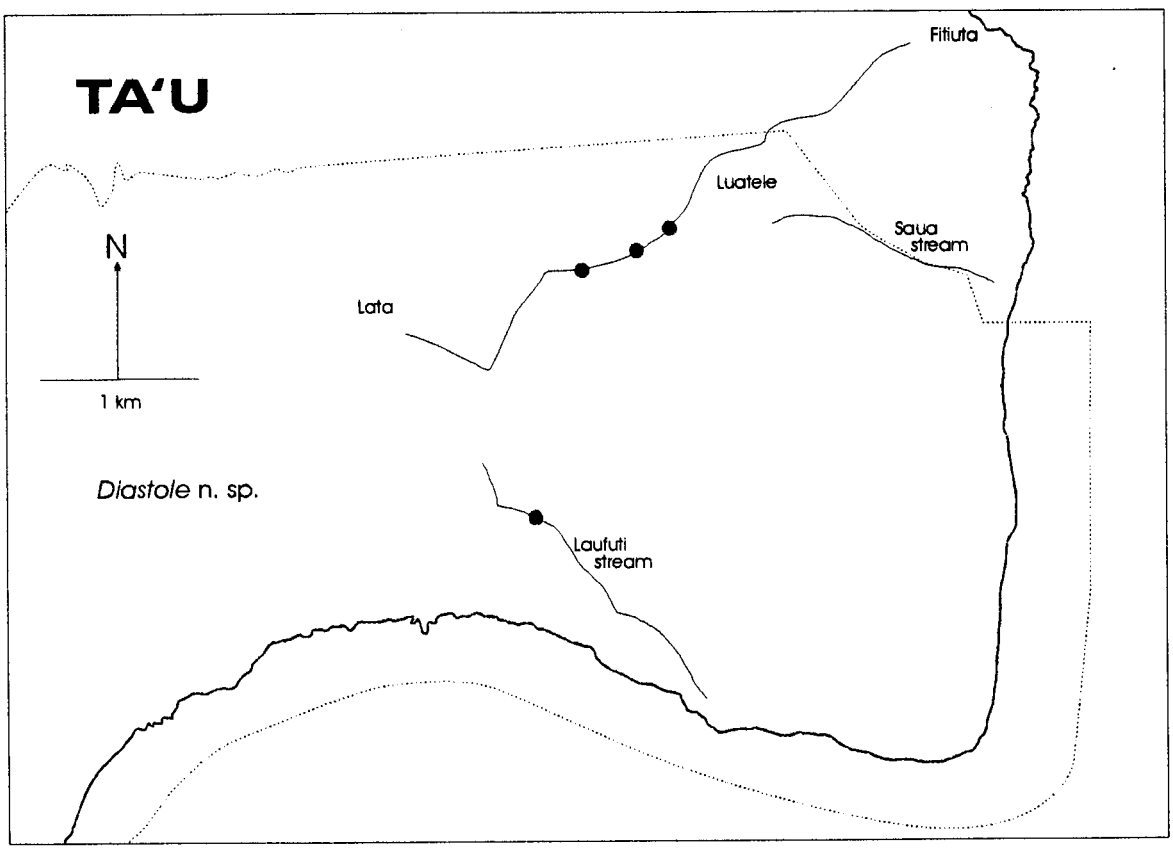

N
1 km
Trochomorpha apia
TUTUILA
Polauta Ridge
Vatia
Amalau
Pago Pago
Pago Pago Harbor

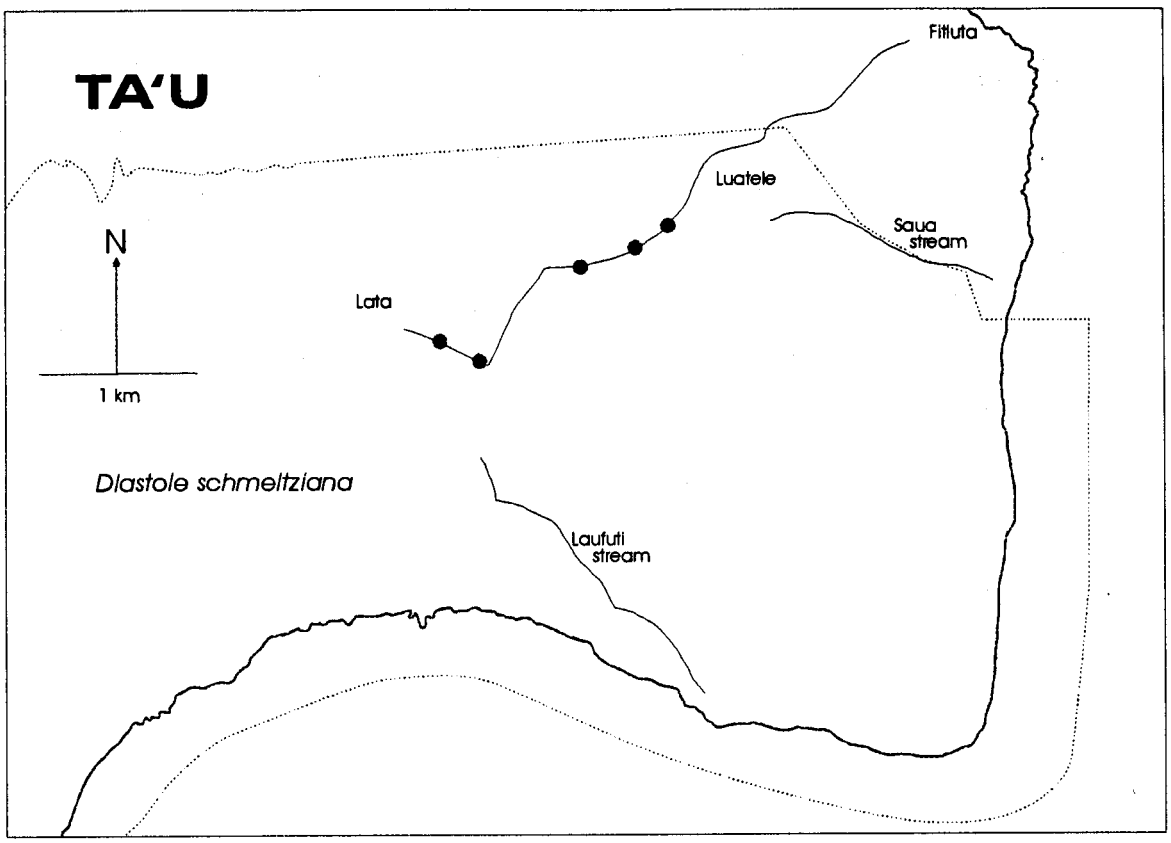

N
1 km
Vaginulus plebeius
TUTUILA
Polauta Ridge
Vatia
Amalau
Pago Pago
Pago Pago Harbor

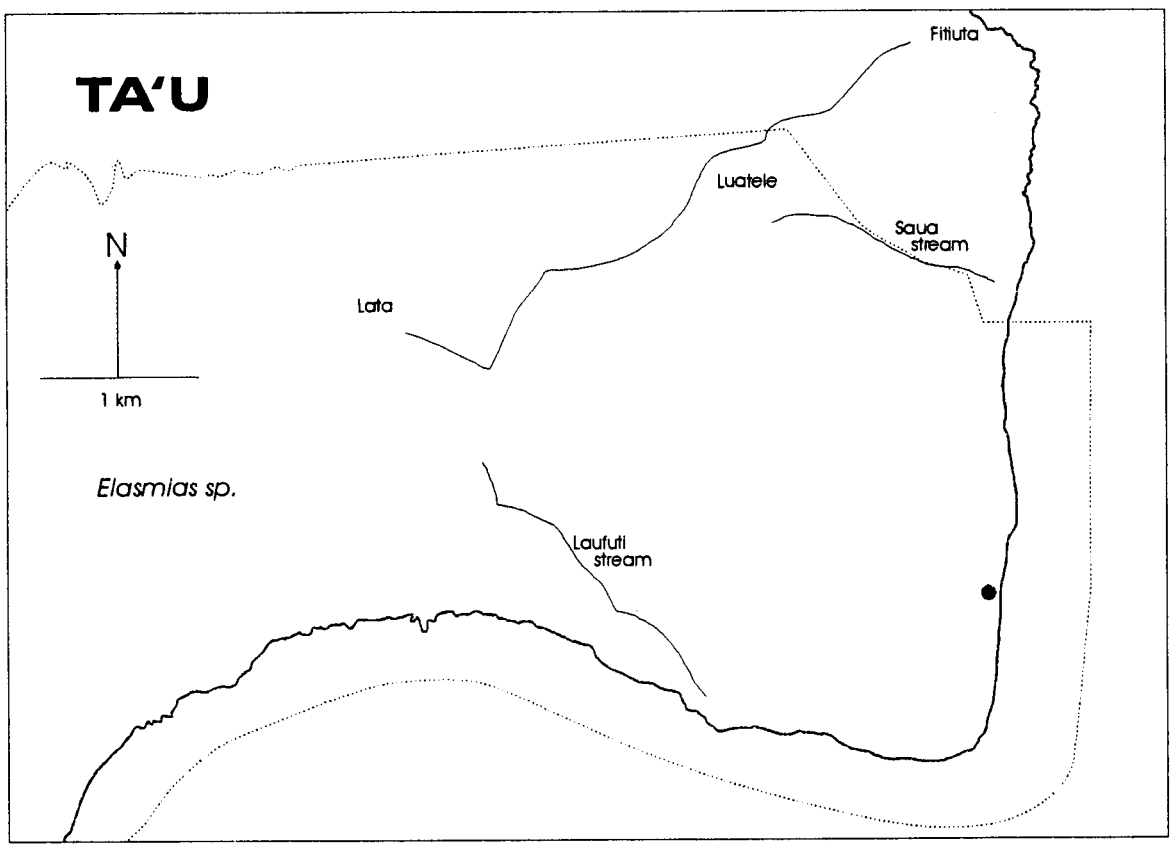

TA'U
Fitiuta
Luatele
Saua stream
Lata
N
1 km
Achatina fulica
Laufuti stream

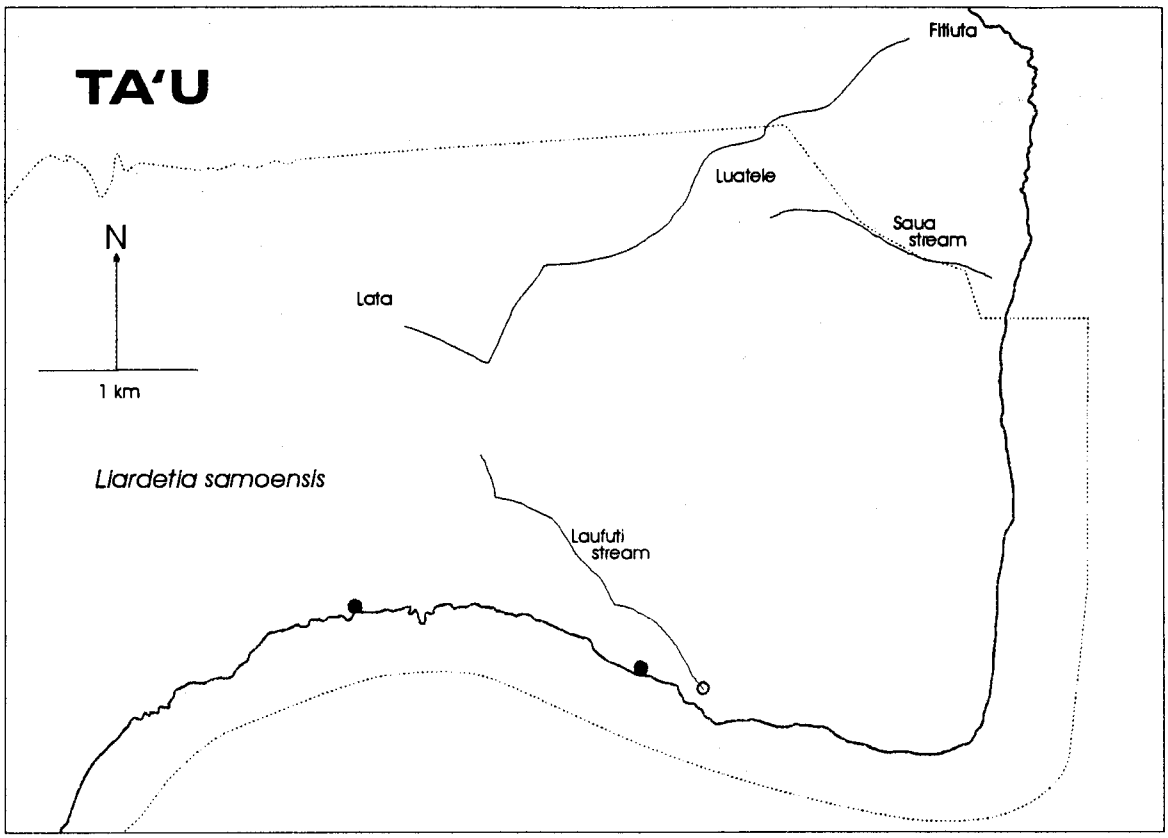

TA'U
Fitiuta
Luatele
Saua stream
Lata
N
1 km
Achatina fulica
Laufuti stream

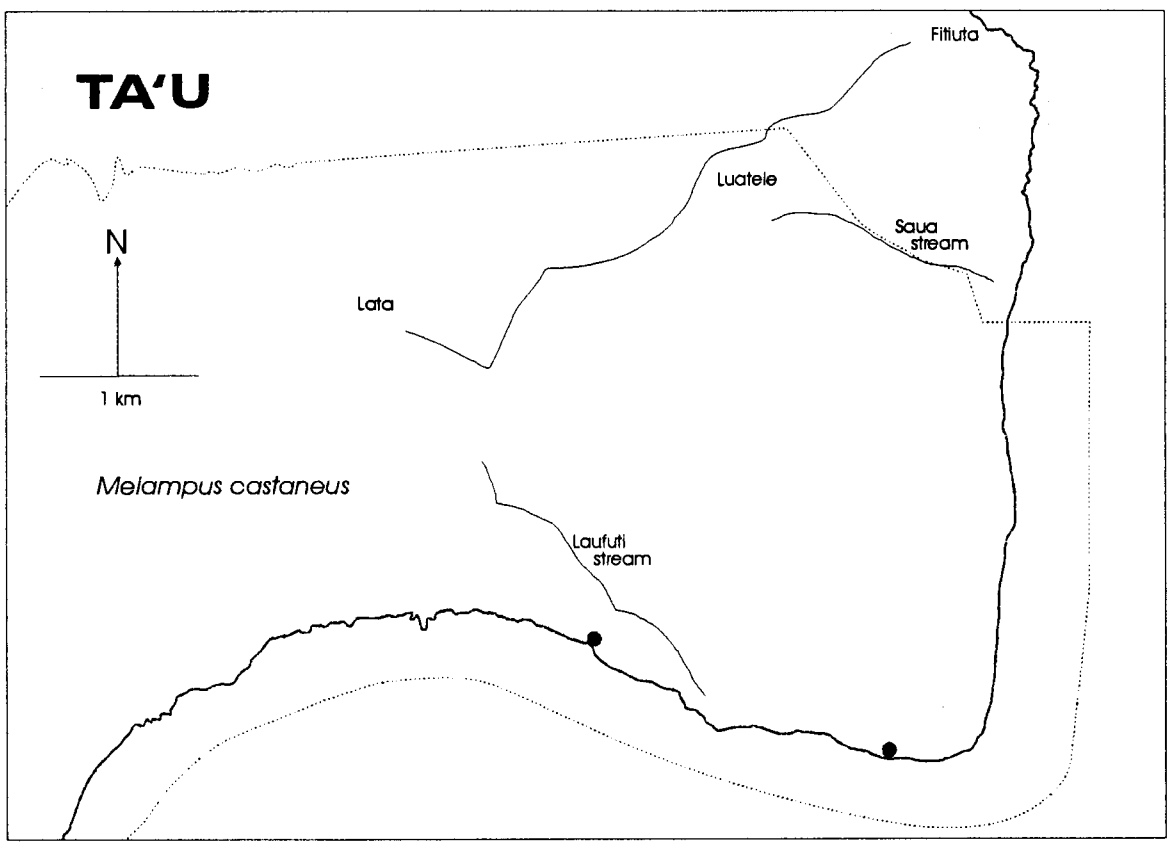

TA'U
Fitiuta
Luatele
Saua stream
Lata
N
1 km
Allopeas clavullnum
Laufuti stream

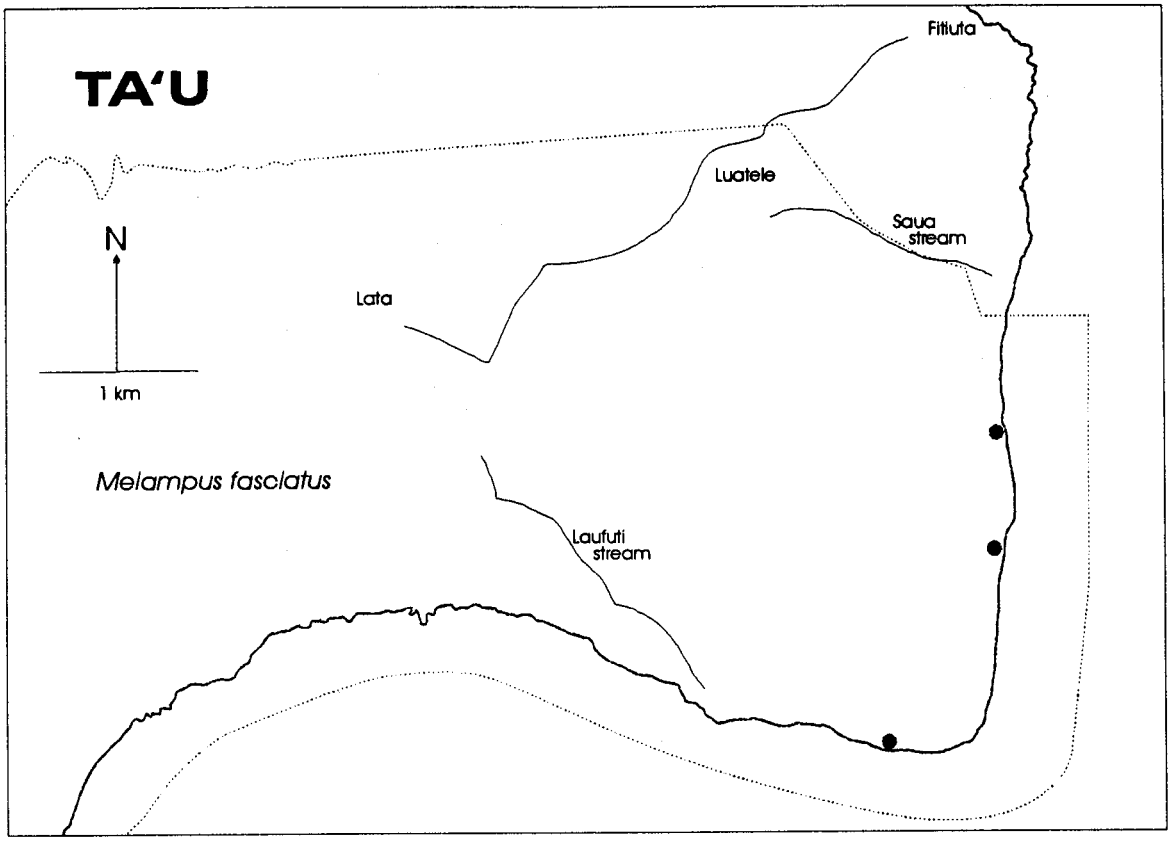

TA'U
Fitiuta
Luatele
Saua stream
Lata
N
1 km
Diastole n. sp.
Laufuti stream

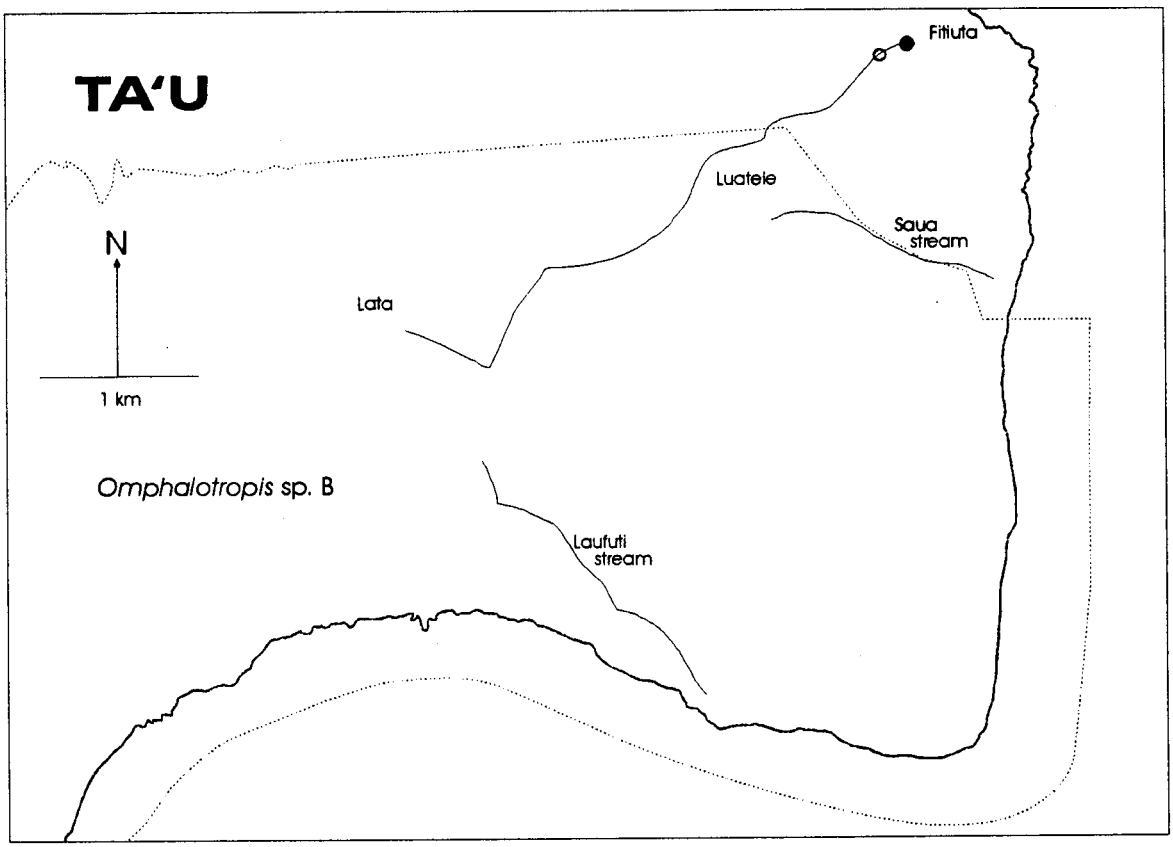

TA'U
Fitiuta
Luatele
Saua stream
Lata
N
1 km
Diastole schmeltziana
Laufuti stream

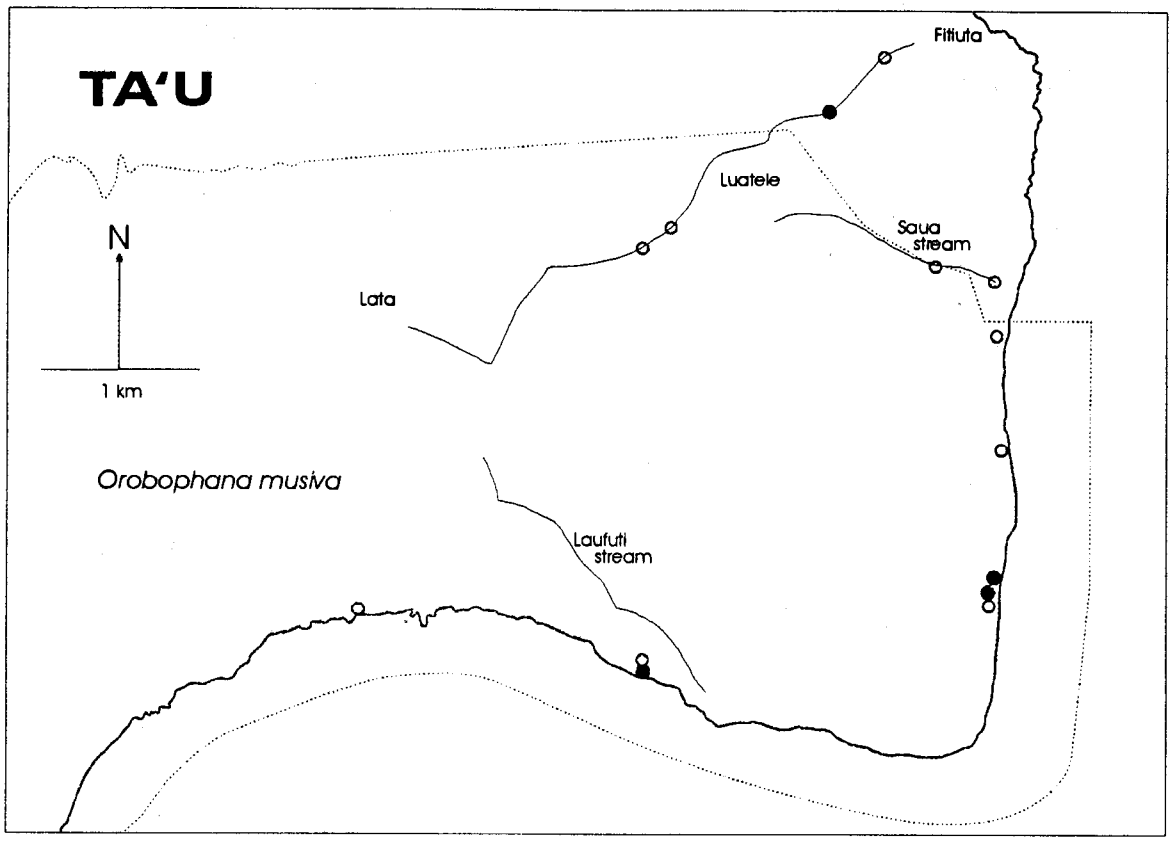

TA'U
Fitiuta
Luatele
Saua stream
Lata
N
1 km
Elasmias sp.
Laufuti stream

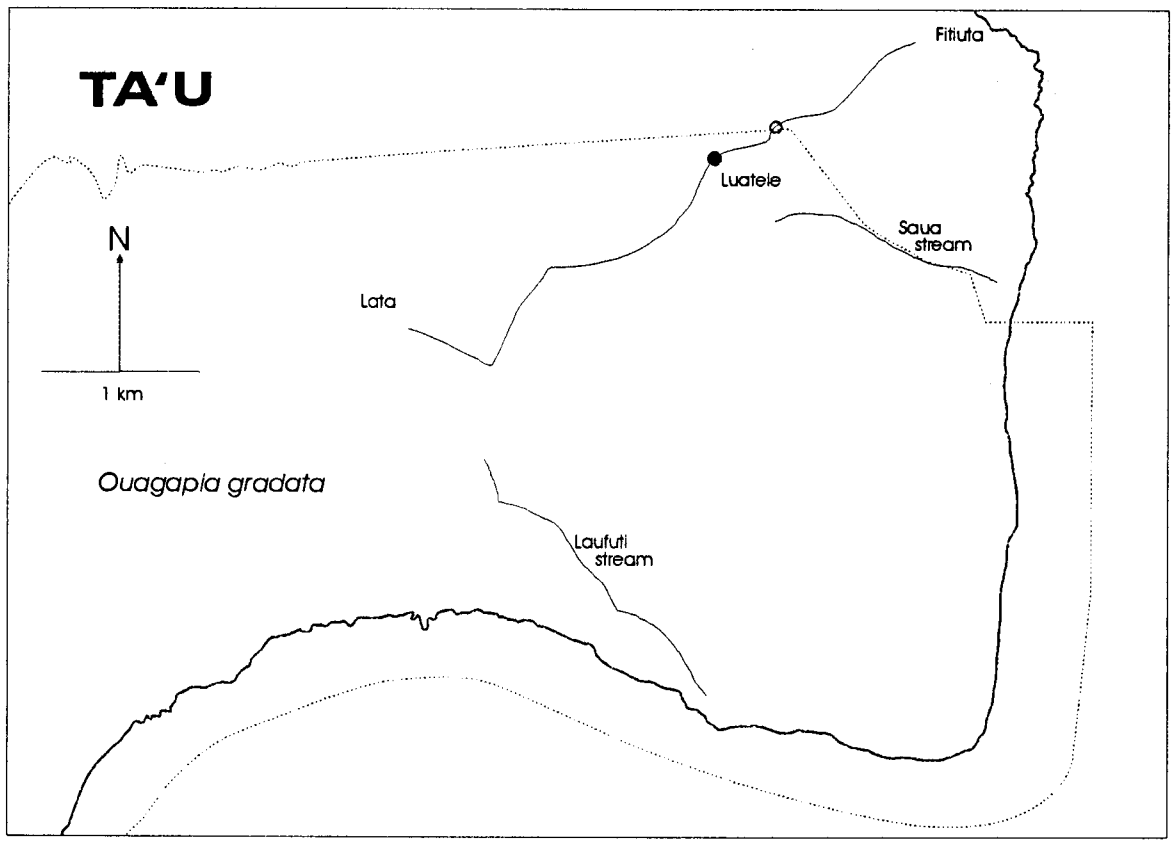

TA'U
Fitiuta
Luatele
Saua stream
Lata
N
1 km
Liardetia samoensis
Laufuti stream

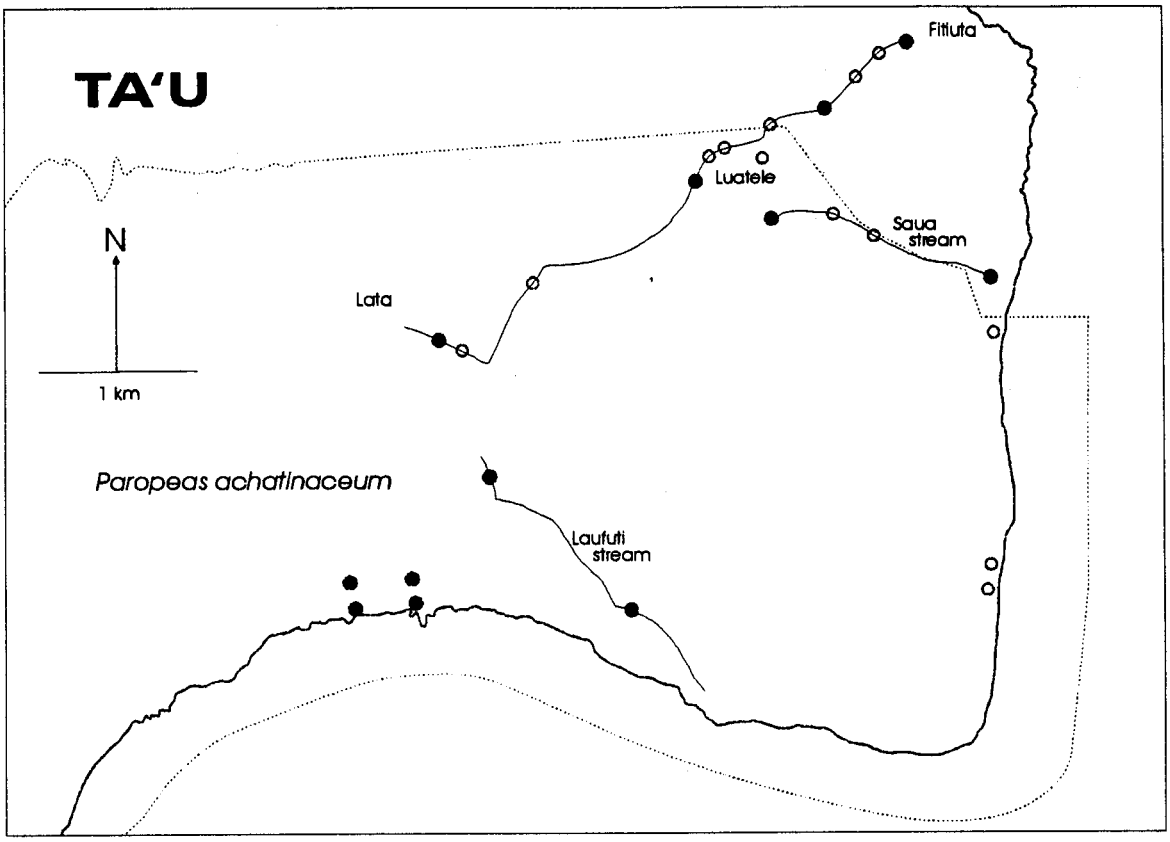

TA'U
Fitiuta
Luatele
Saua stream
Lata
N
1 km
Melampus castaneus
Laufuti stream

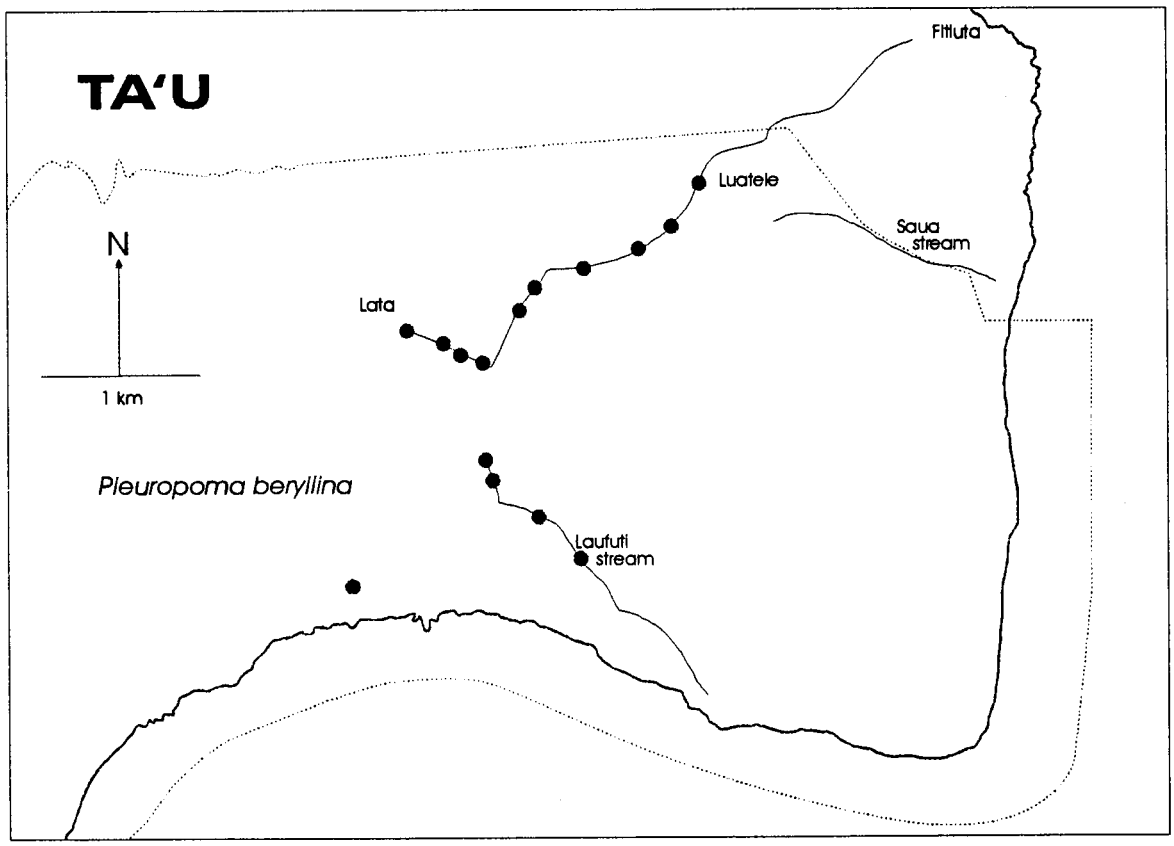

TA'U
Fituta
Luatele
Saua stream
Lata
N
1 km
Melampus fasciatus
Laufuti stream

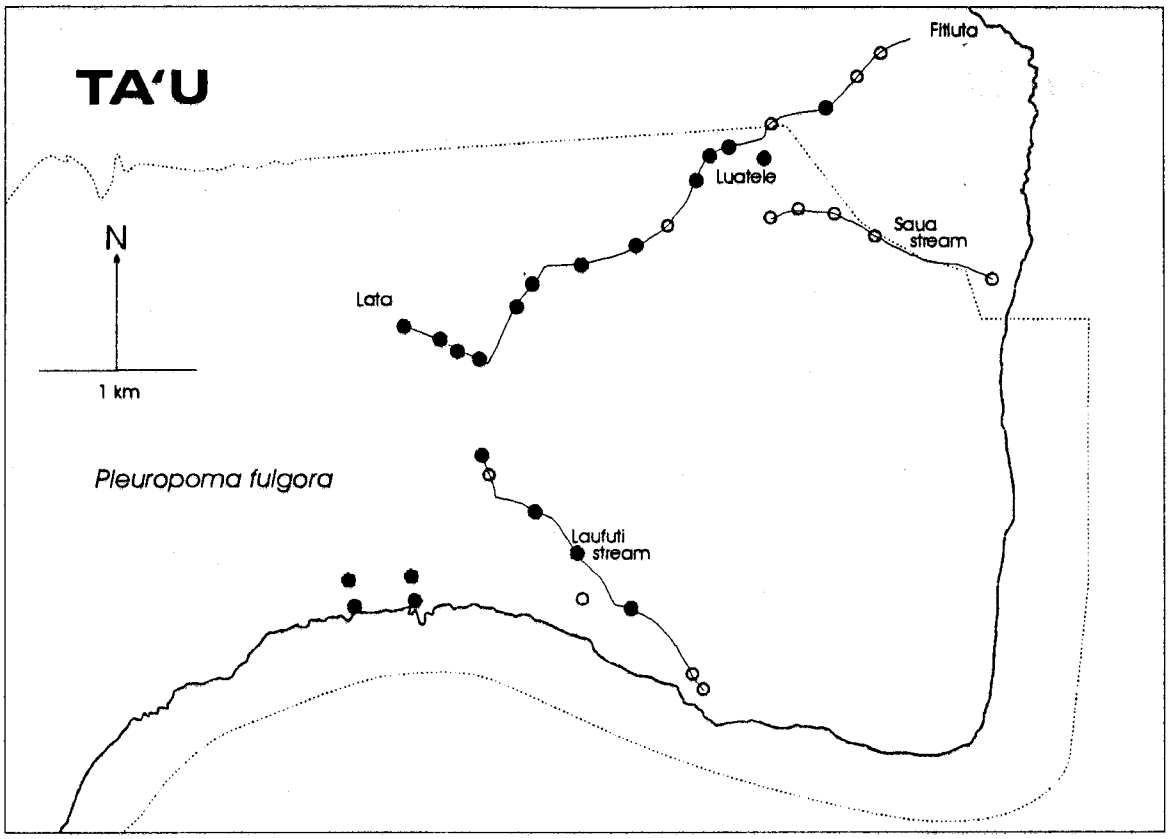

TA'U
Fituta
Luatele
Saua stream
Lata
N
1 km
Omphalotropis sp. B
Laufuti stream

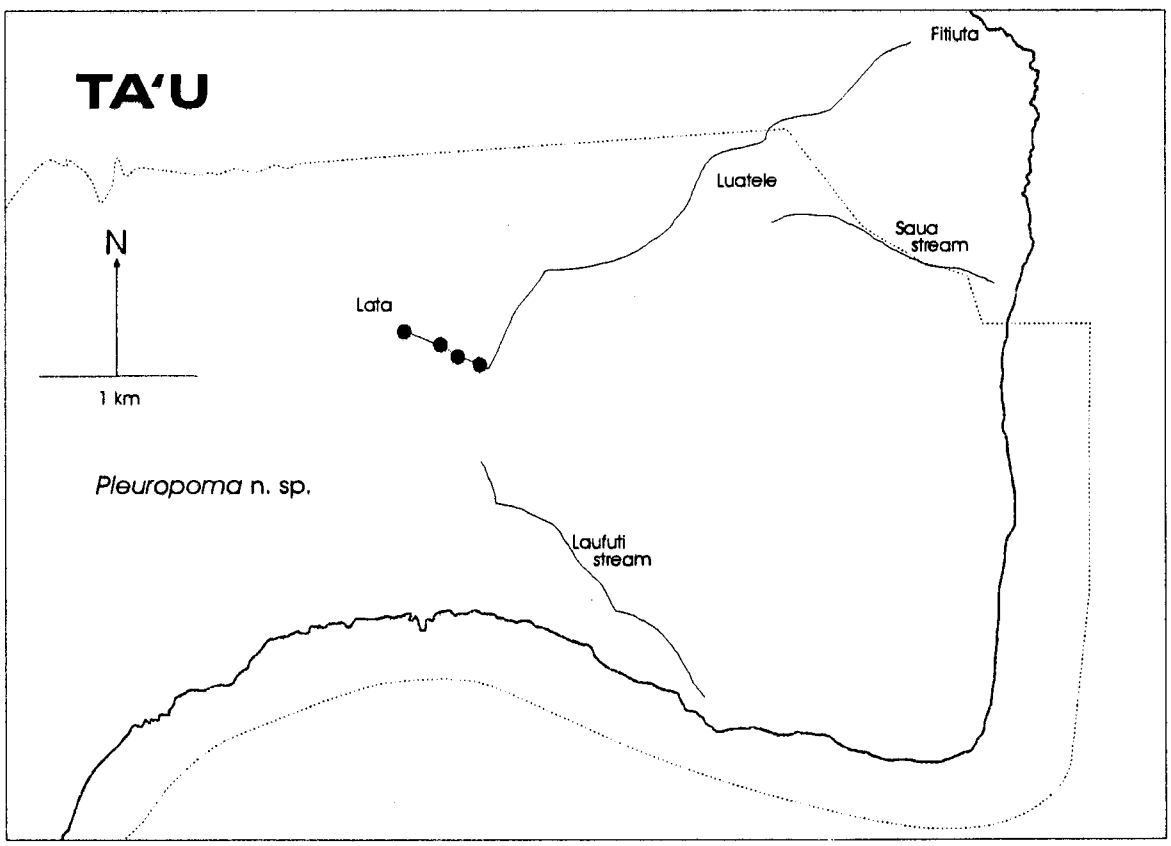

TA'U
Fitiuta
Luatele
Saua stream
Lata
N
1 km
Orobophana musiva
Laufuti stream

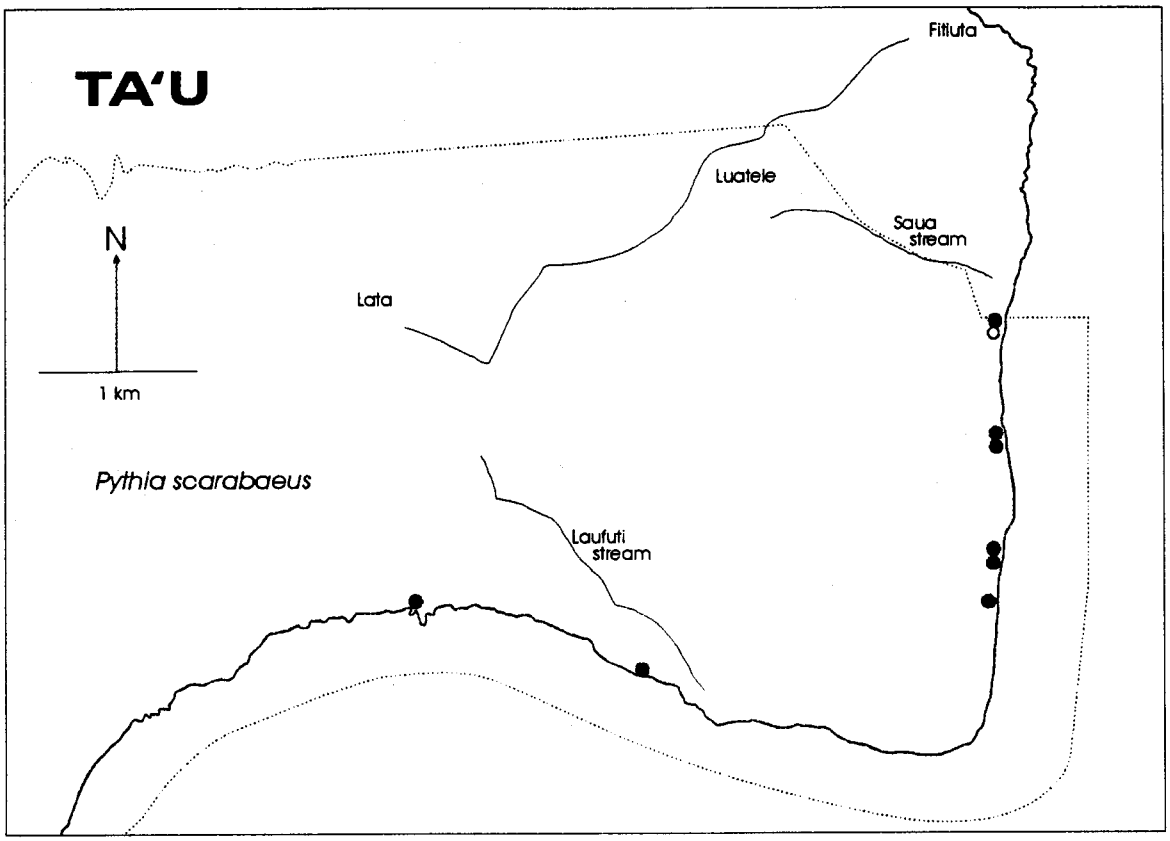

TA'U
Fitiuta
Luatele
Saua stream
Lata
N
1 km
Ouagapia gradata
Laufuti stream

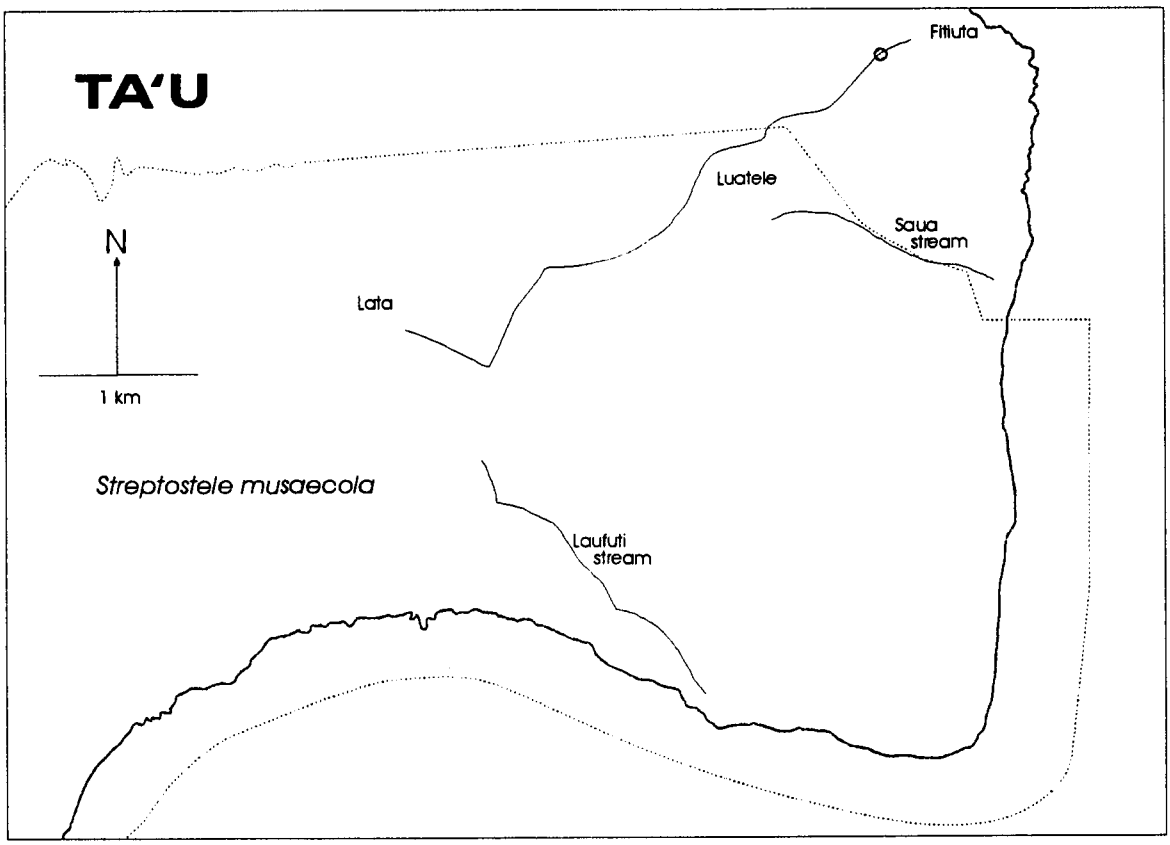

TA'U
Fituta
Luatele
Saua stream
Lata
N
1 km
Paropeas achatinaceum
Laufuti stream

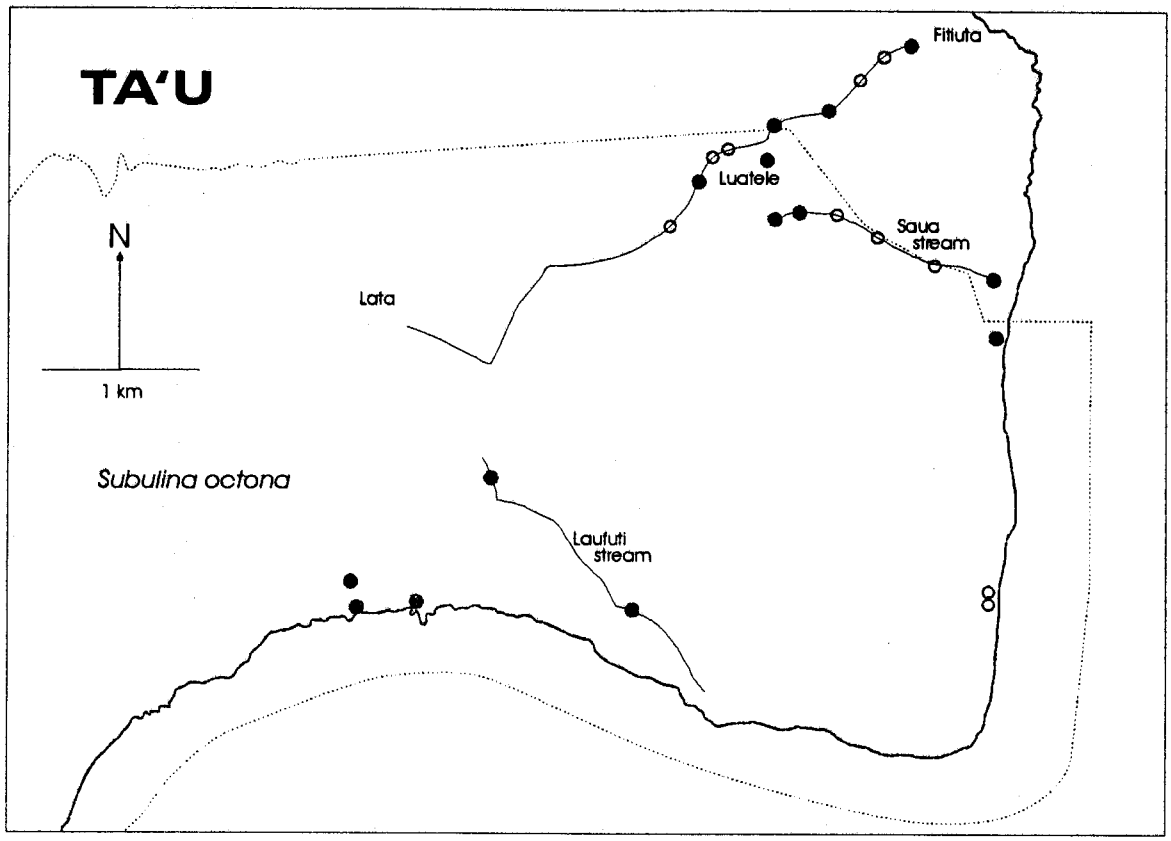

TA'U
Fituta
Luatele
Saua stream
Lata
N
1 km
Pleuropoma beryllina
Laufuti stream

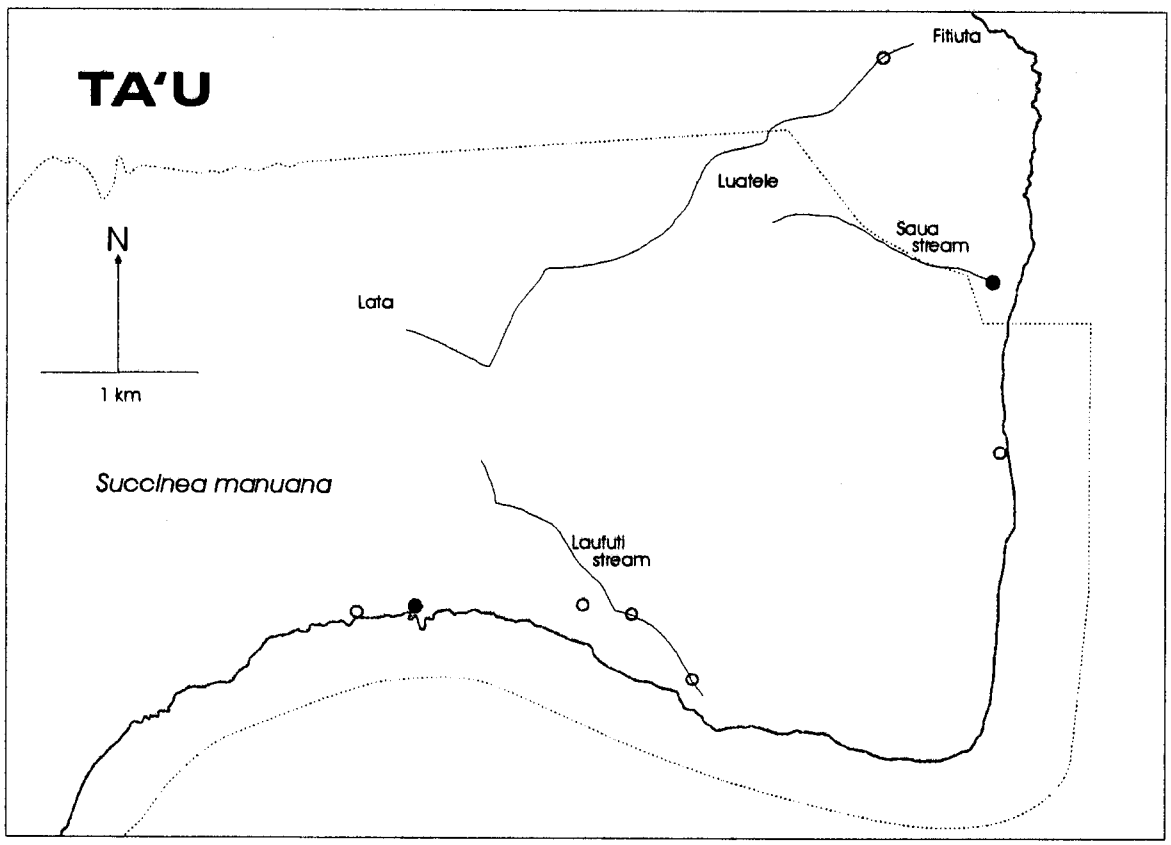

TA'U
Fitiuta
Luatele
Saua stream
Lata
N
1 km
Pleuropoma fulgora
Laufuti stream

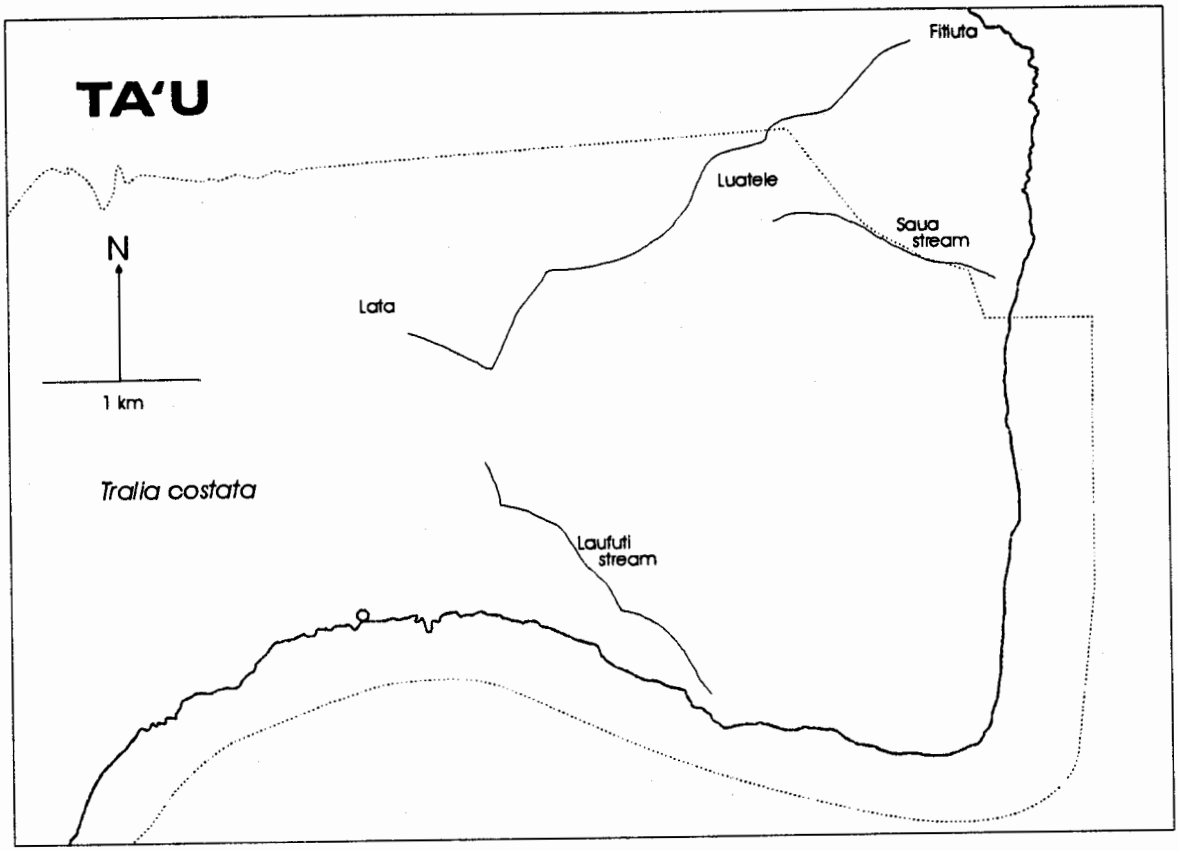

TA'U
Fitiuta
Luatele
Saua stream
Lata
N
1 km
Pleuropoma n. sp.
Laufuti stream

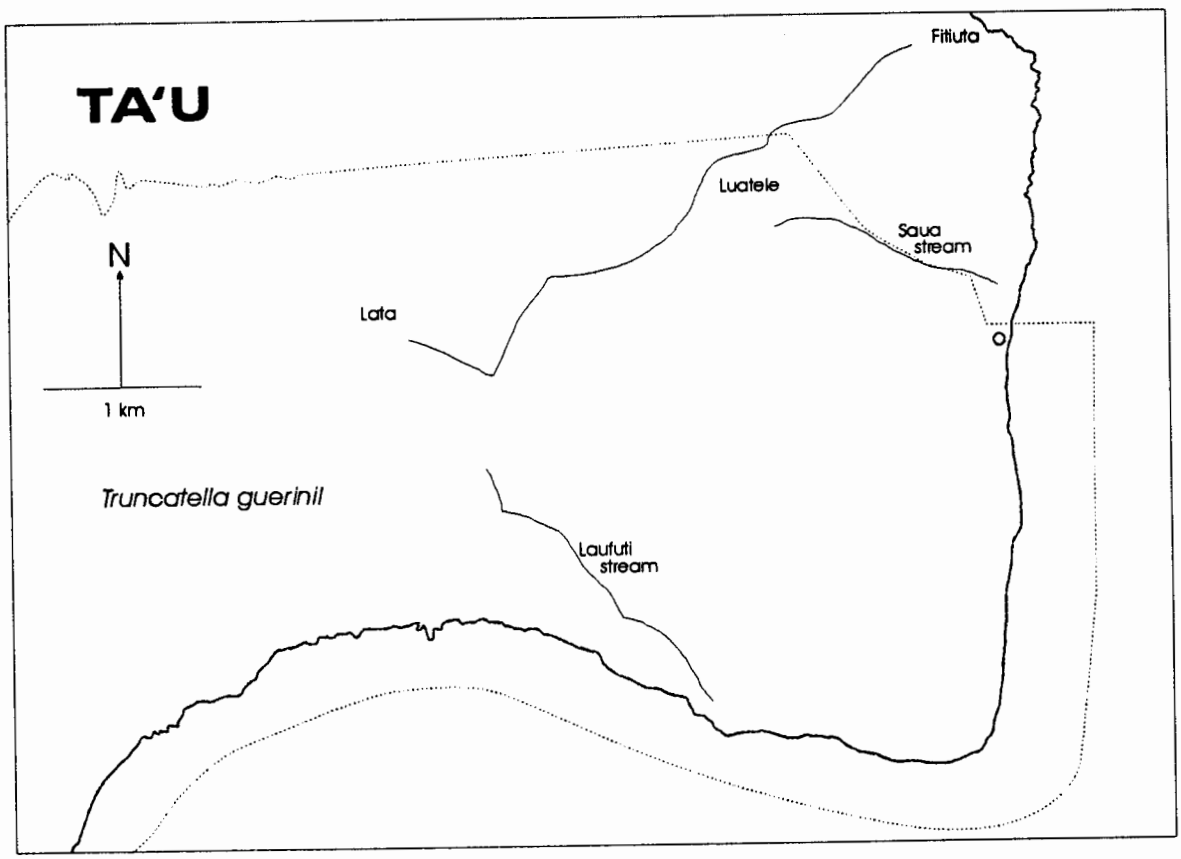

TA'U
Fitiuta
Luatele
Saua stream
Lata
N
1 km
Pythia scarabaeus
Laufuti stream

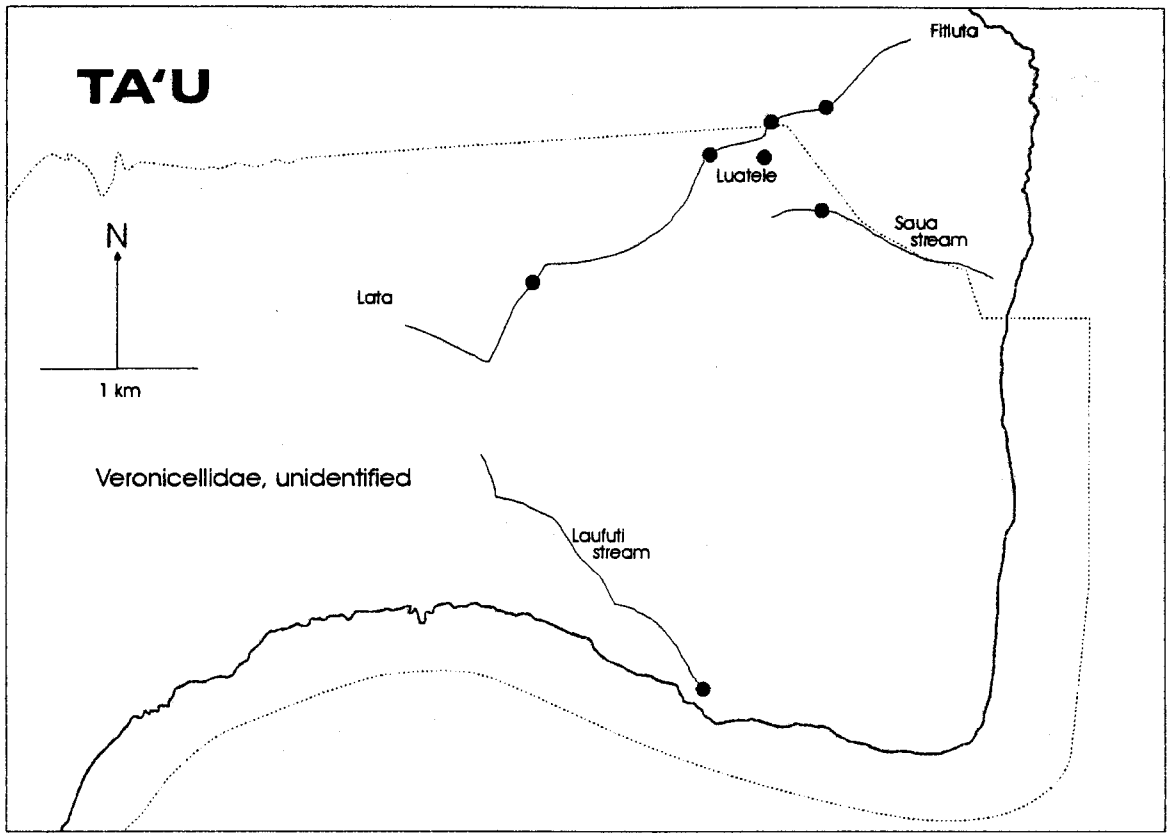

TA'U
Fitiuta
Luatele
Saua stream
Lata
N
1 km
Streptostele musaecola
Laufuti stream

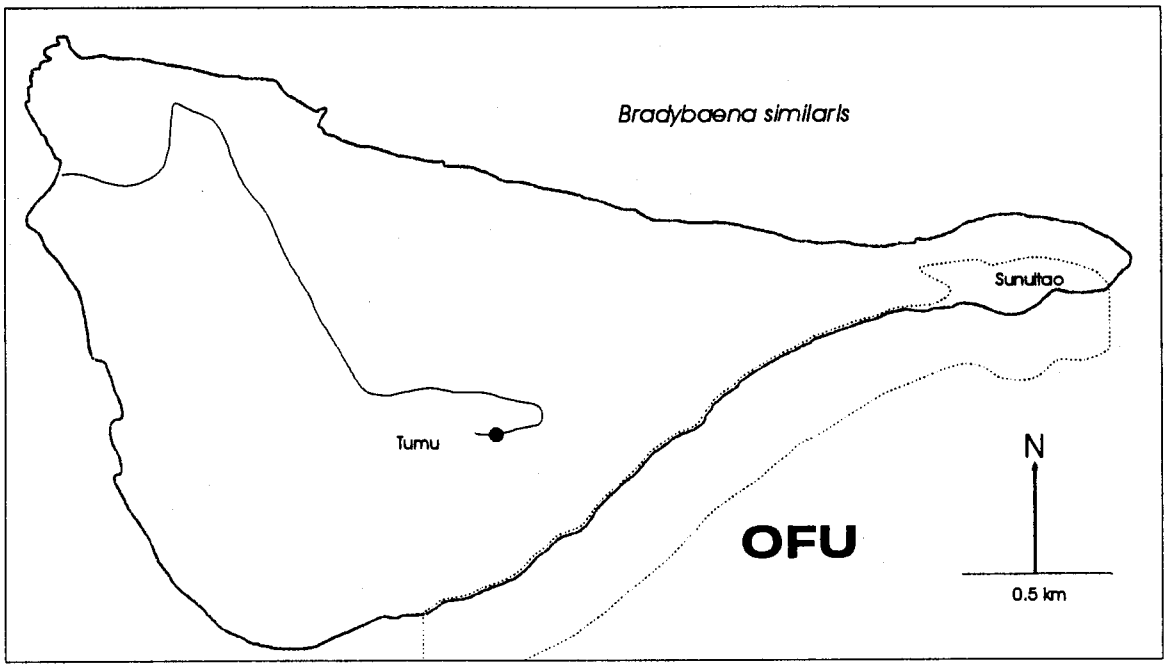

TA'U
Fitiuta
Luatele
Saua stream
Lata
N
1 km
Subulina octona
Laufuti stream

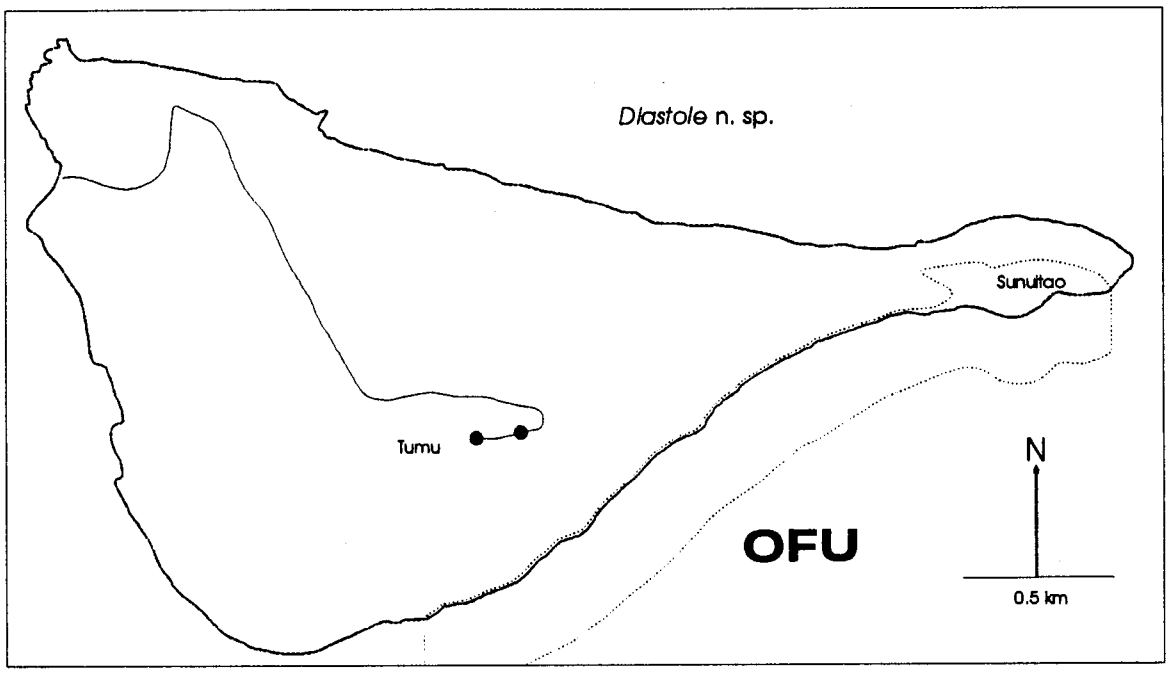

TA'U
Fitiuta
Luatele
Saua stream
Lata
N
1 km
Succinea manuana
Laufuti stream

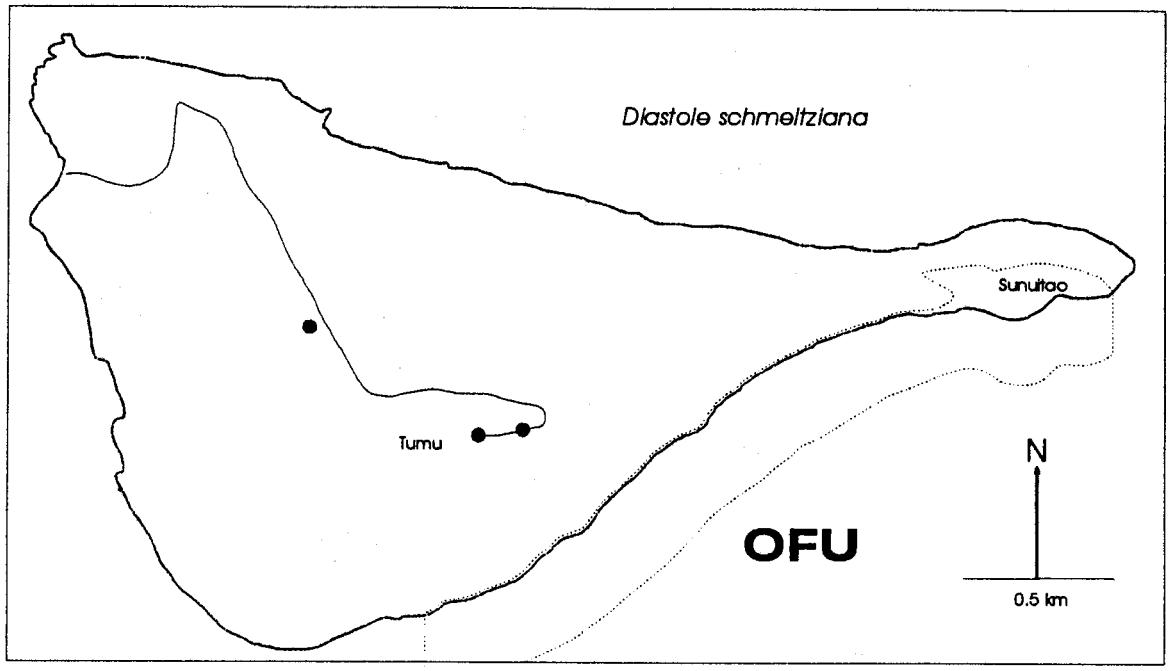

TA'U
Fitiuta
Luatele
Saua stream
Lata
N
1 km
Tralia costata
Laufuti stream

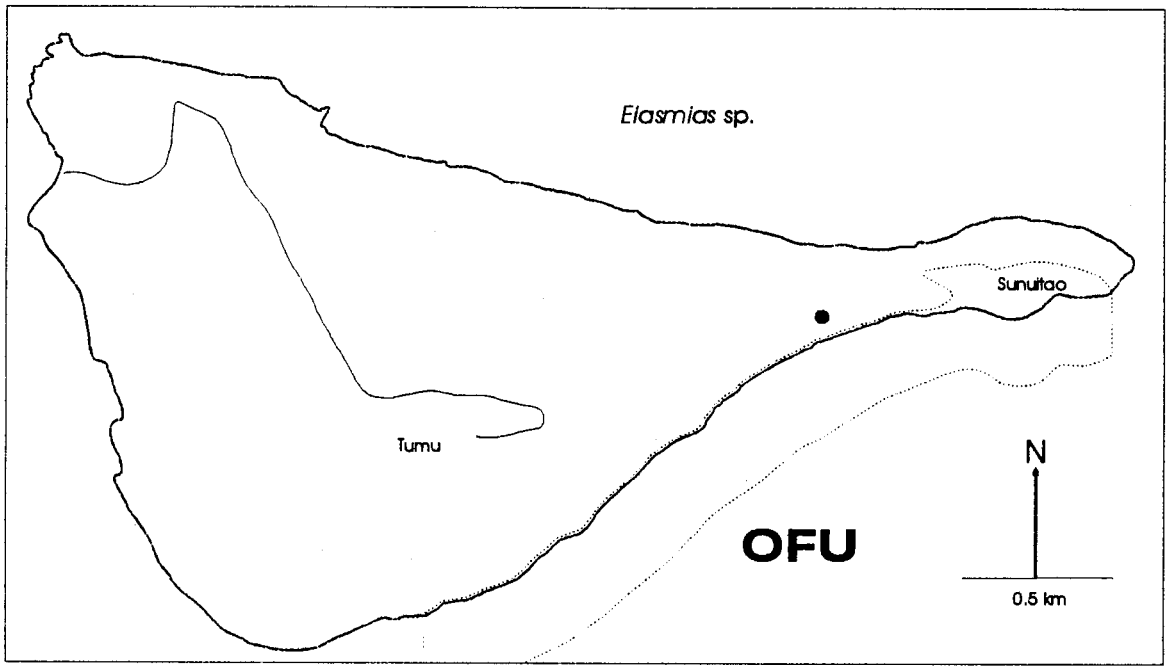

TA'U
Fitiuta
Luatele
Saua stream
Lata
N
1 km
Truncatella guerinii
Laufuti stream

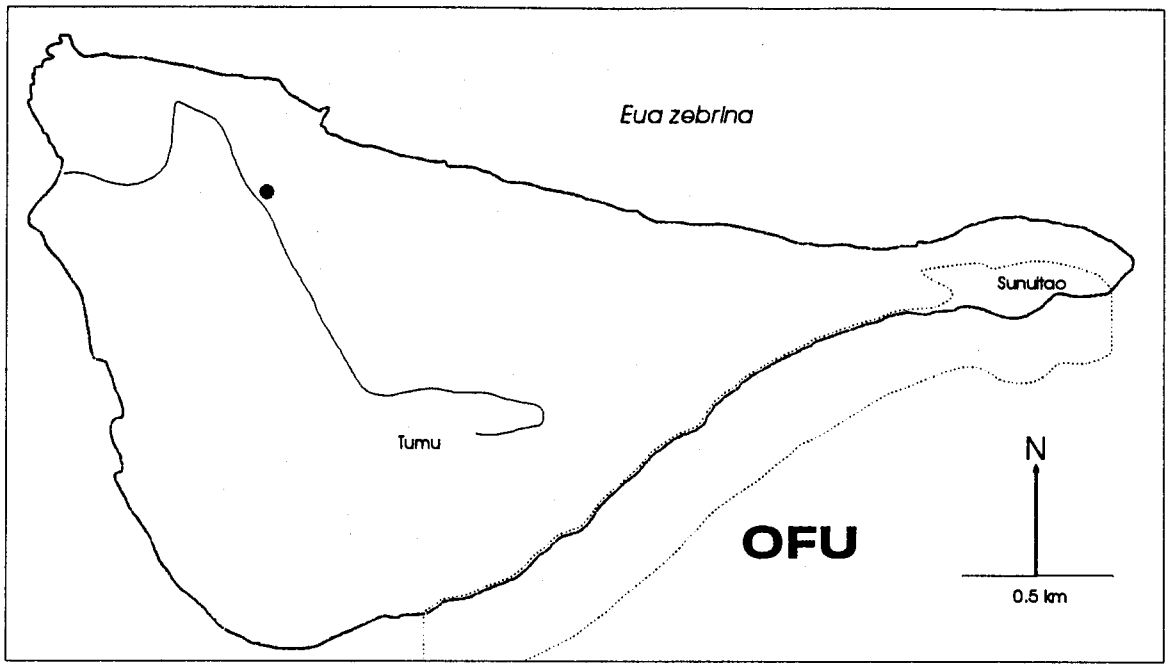

TA'U
Fitiuta
Luatele
Saua stream
Lata
N
1 km
Veronicellidae, unidentified
Laufuti stream

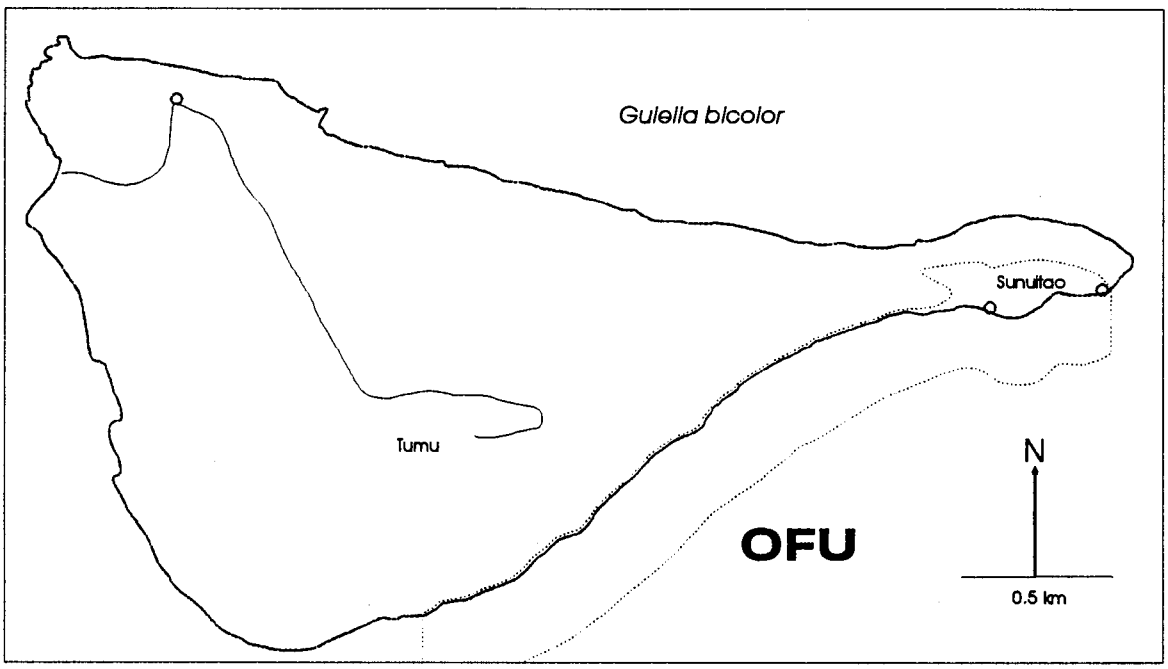

Bradybaena similaris
Sunuitao
Tumu
OFU
N
0.5 km

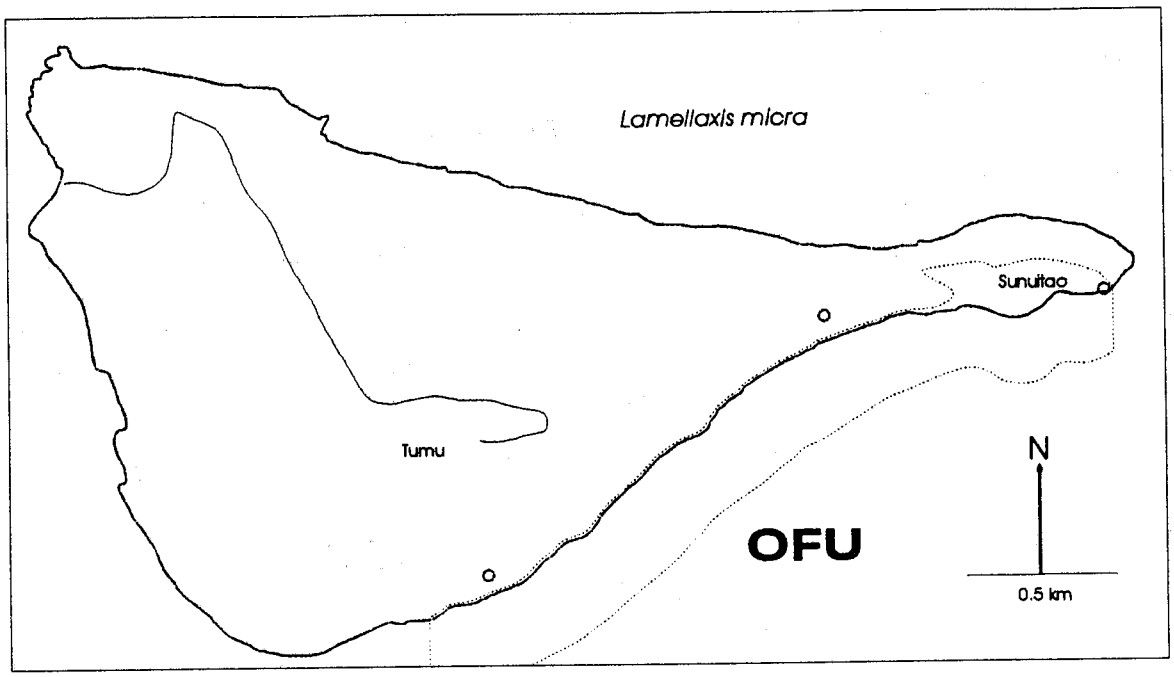

Diastole n. sp.
Sunuitao
Tumu
OFU
N
0.5 km

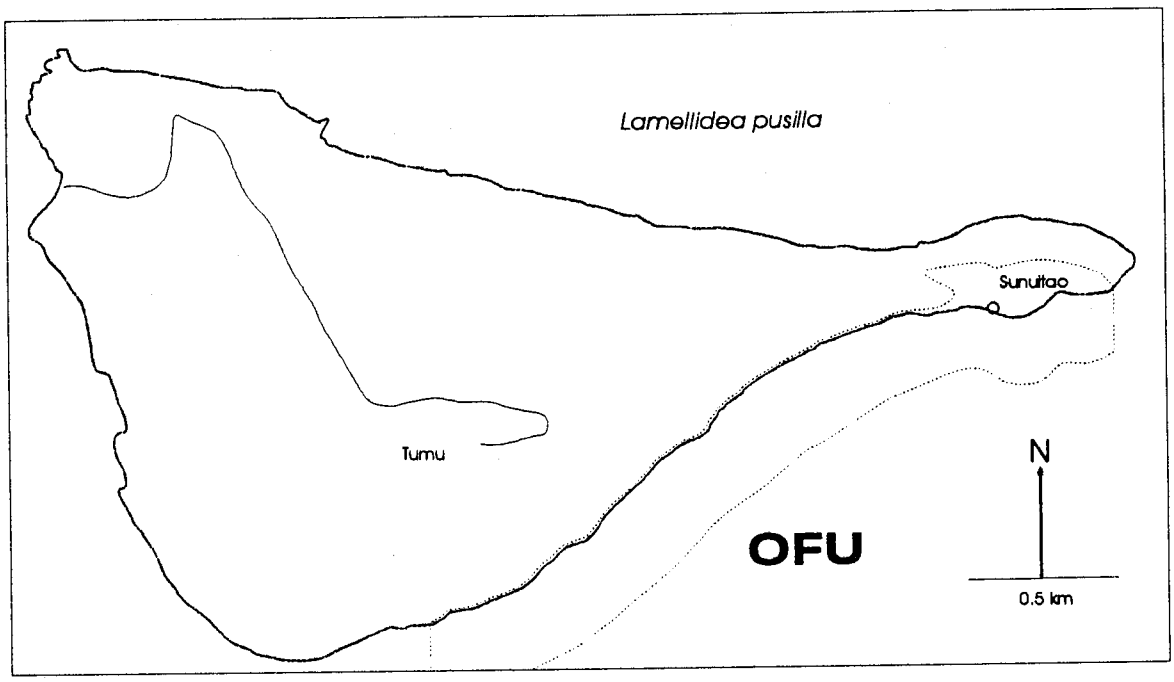

Diastole schmeltziana
Sunuitao
Tumu
OFU
N
0.5 km

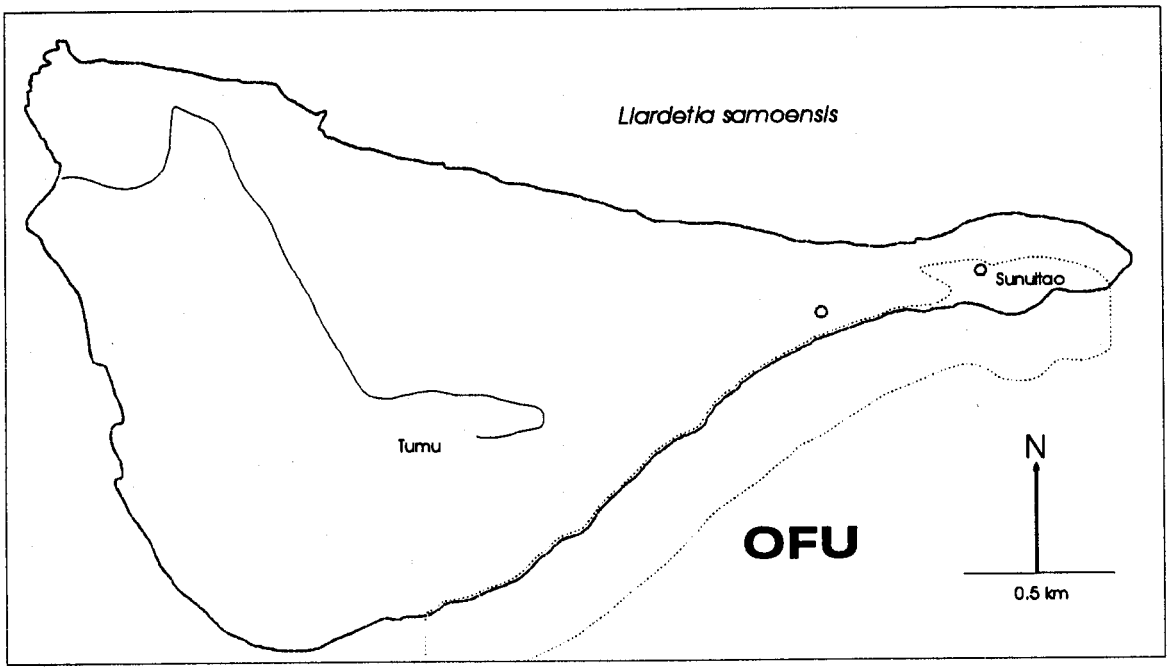

Elasmias sp.
Sunuitao
Tumu
OFU
N
0.5 km

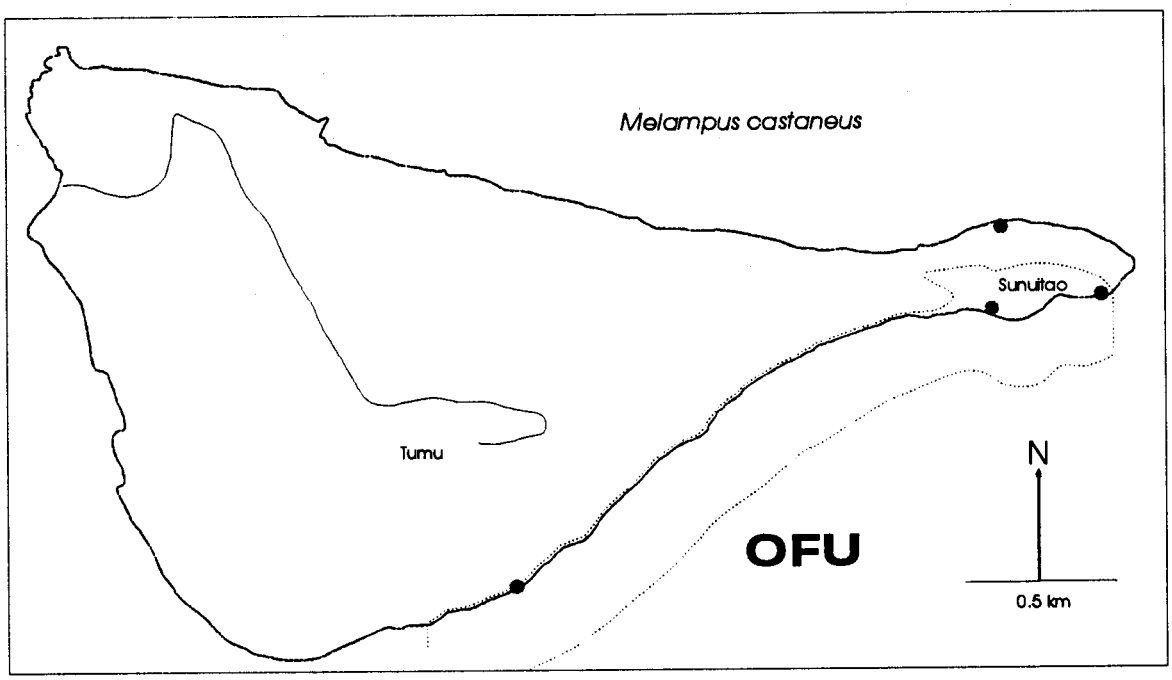

Eua zebrina
Sunuitao
Tumu
OFU
N
0.5 km

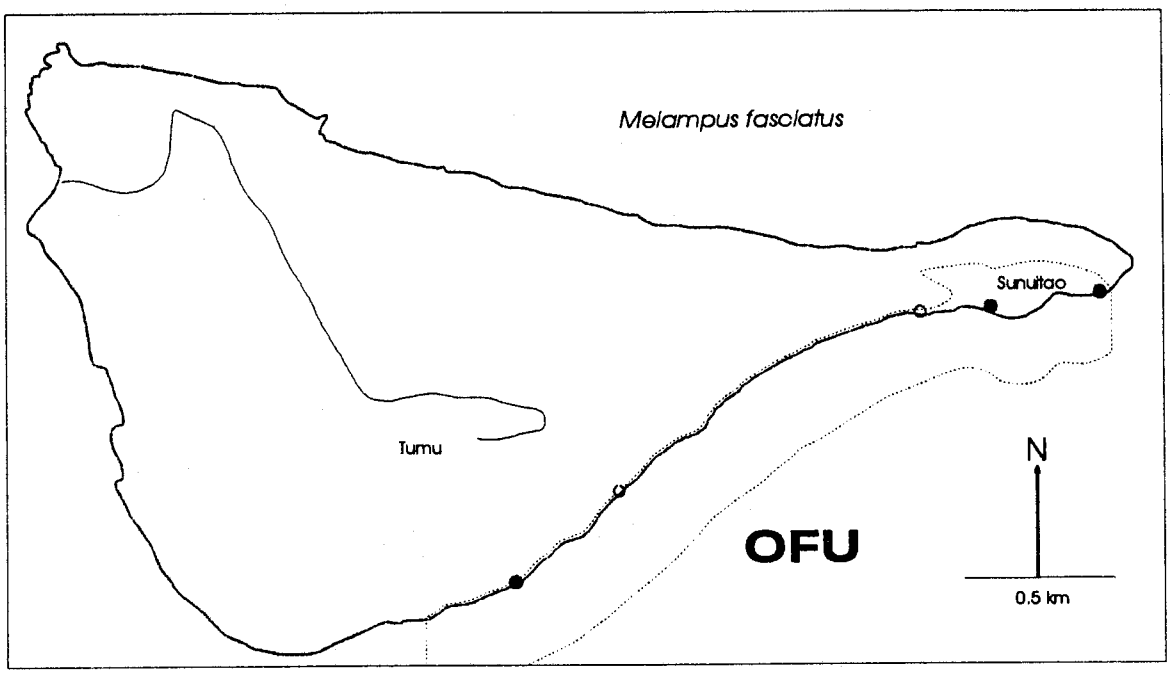

Gulella bicolor
Sunuitao
Tumu
OFU
N
0.5 km

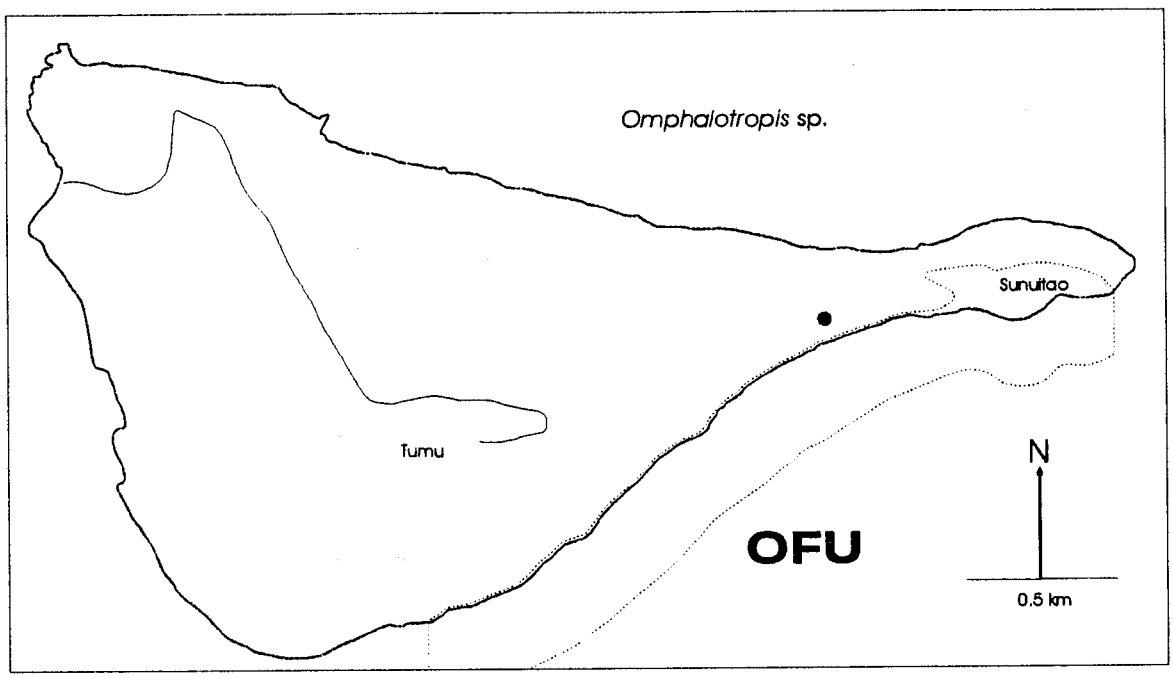

Lamellaxis micra
Sunuitao
Tumu
OFU
N
0.5 km

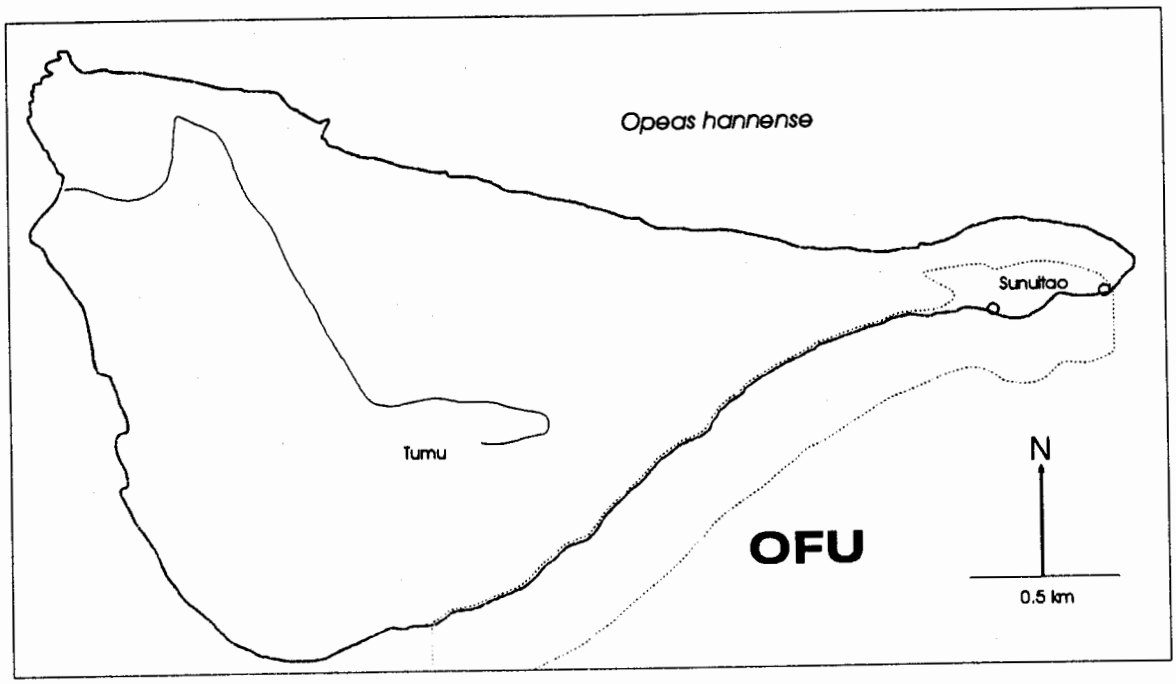

Lamellidea pusilla
Sunuitao
Tumu
OFU
N
0.5 km

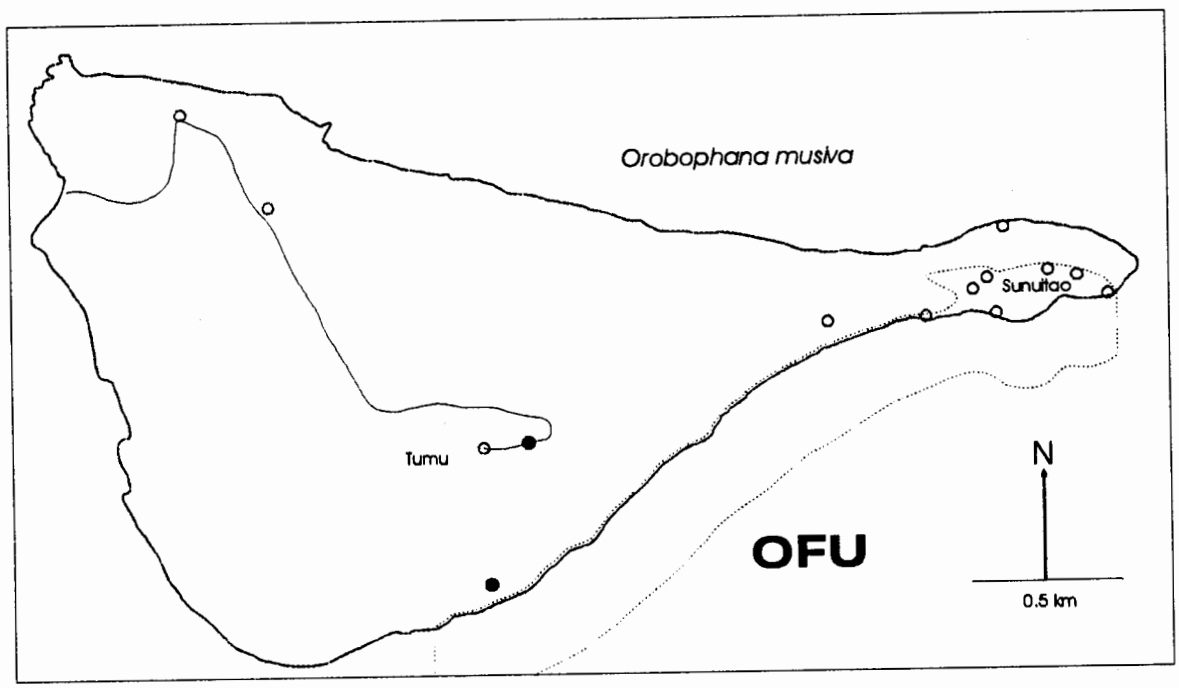

Liardetia samoensis
Sunuitao
Tumu
OFU
N
0.5 km

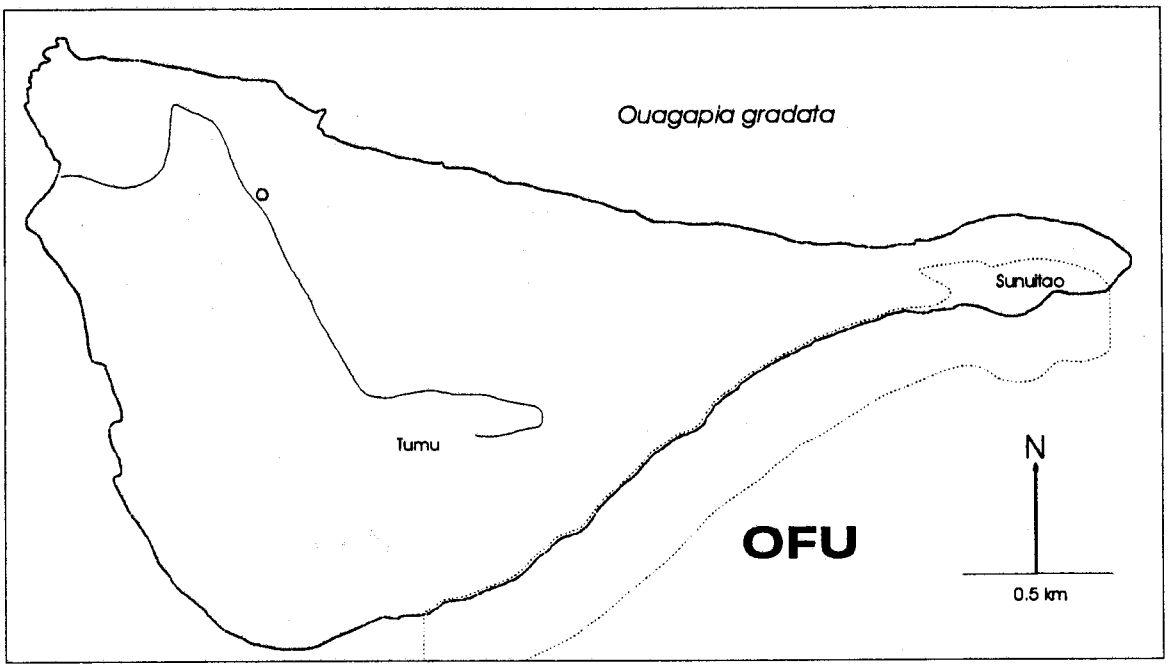

Melampus castaneus
Sunuitao
Tumu
OFU
N
0.5 km

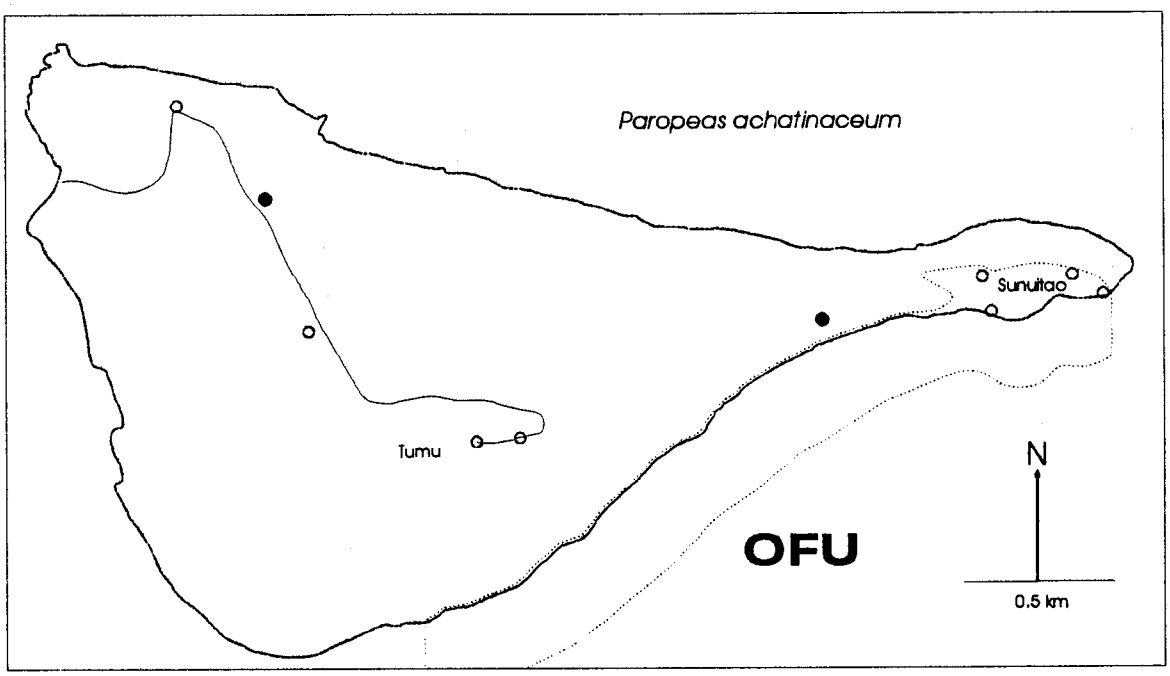

Melampus fasciatus
Sunuitao
Tumu
OFU
N
0.5 km

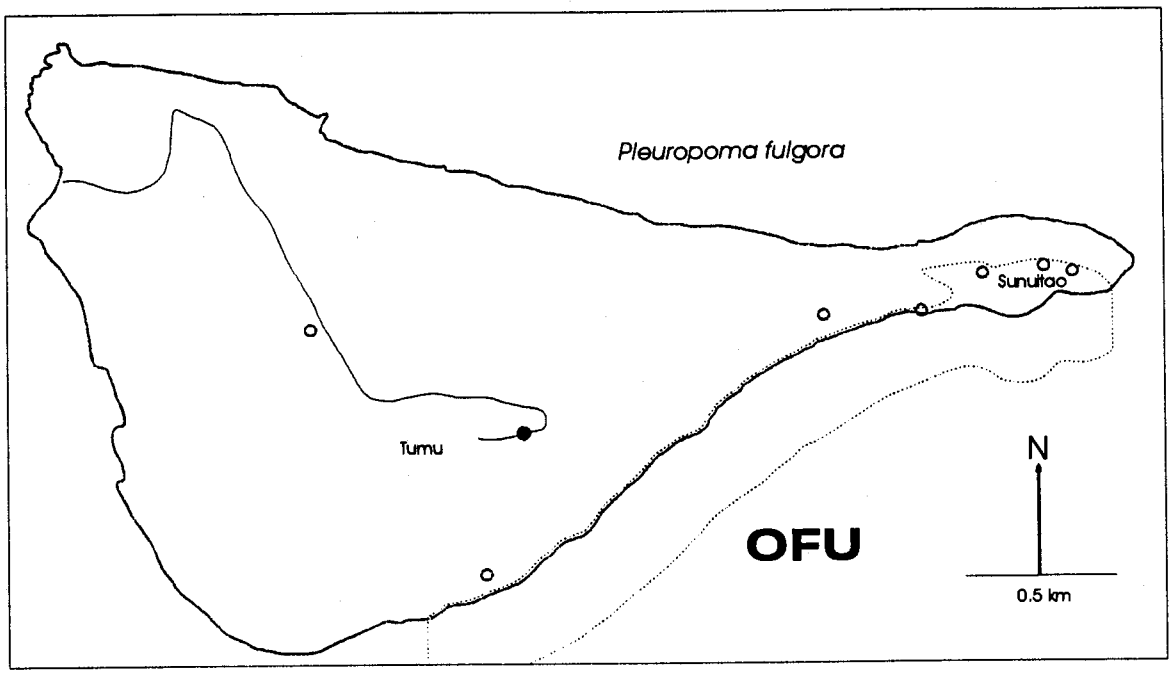

Omphalotropis sp.
Sunuitao
Tumu
OFU
N
0.5 km

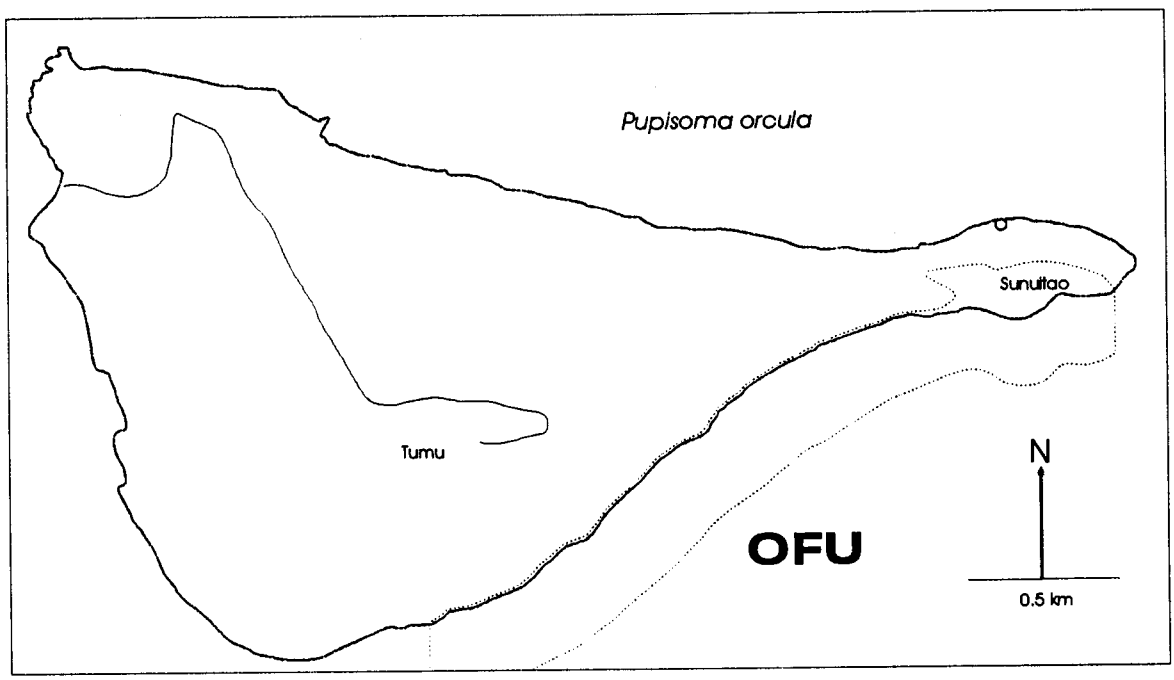

Opeas hannense
Sunuitao
Tumu
OFU
N
0.5 km

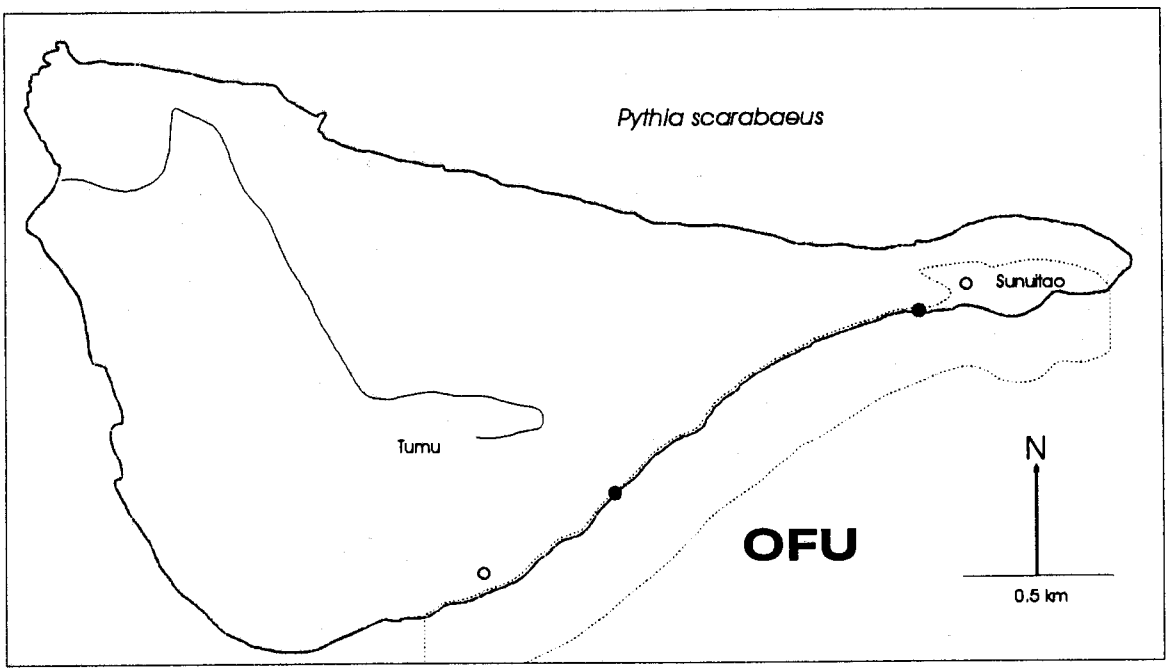

Orobophana musiva
Sunuitao
Tumu
OFU
N
0.5 km

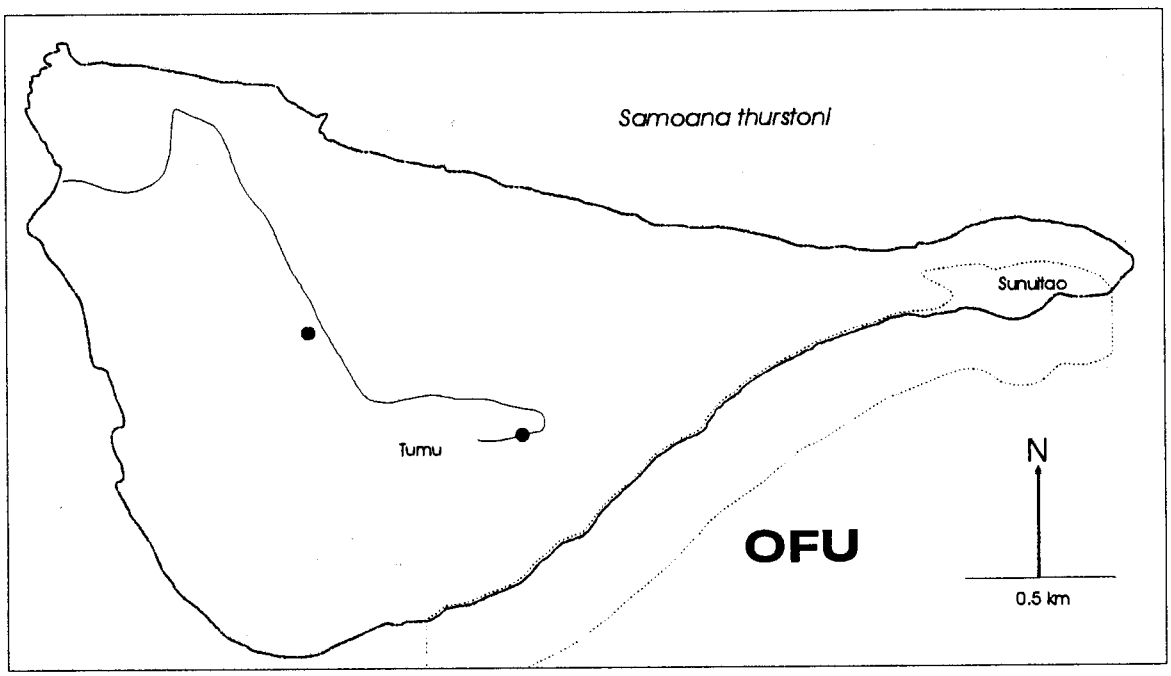

Ouagapia gradata
Sunuitao
Tumu
N
OFU
0.5 km

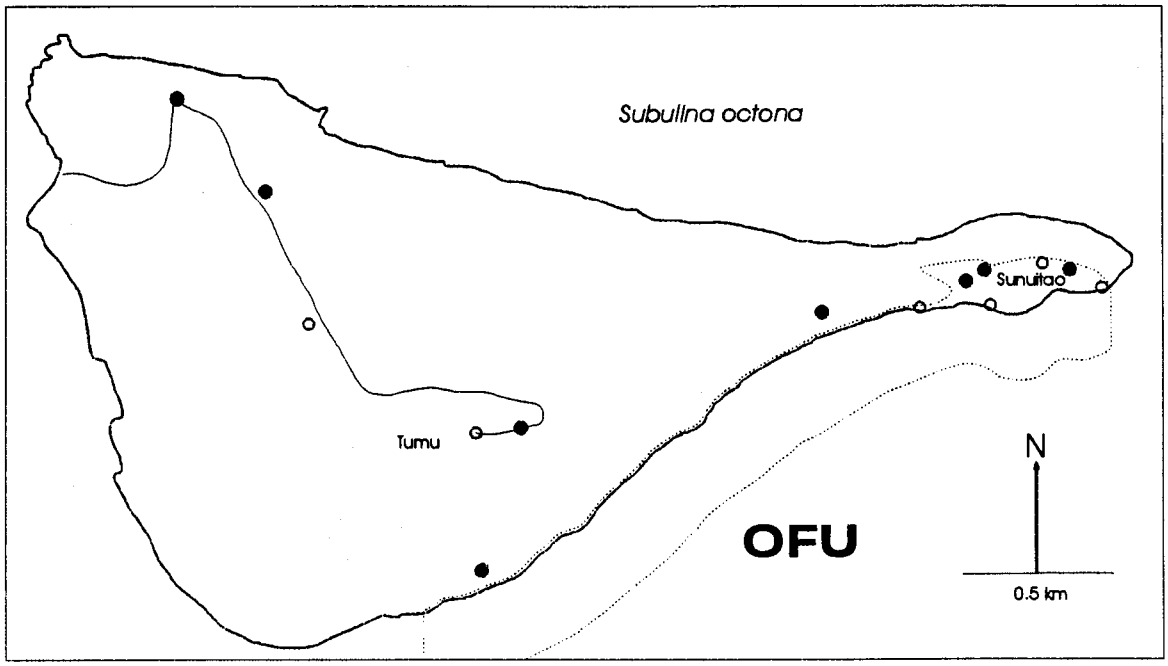

Paropeas achatinaceum
Sunuitao
Tumu
N
OFU
0.5 km

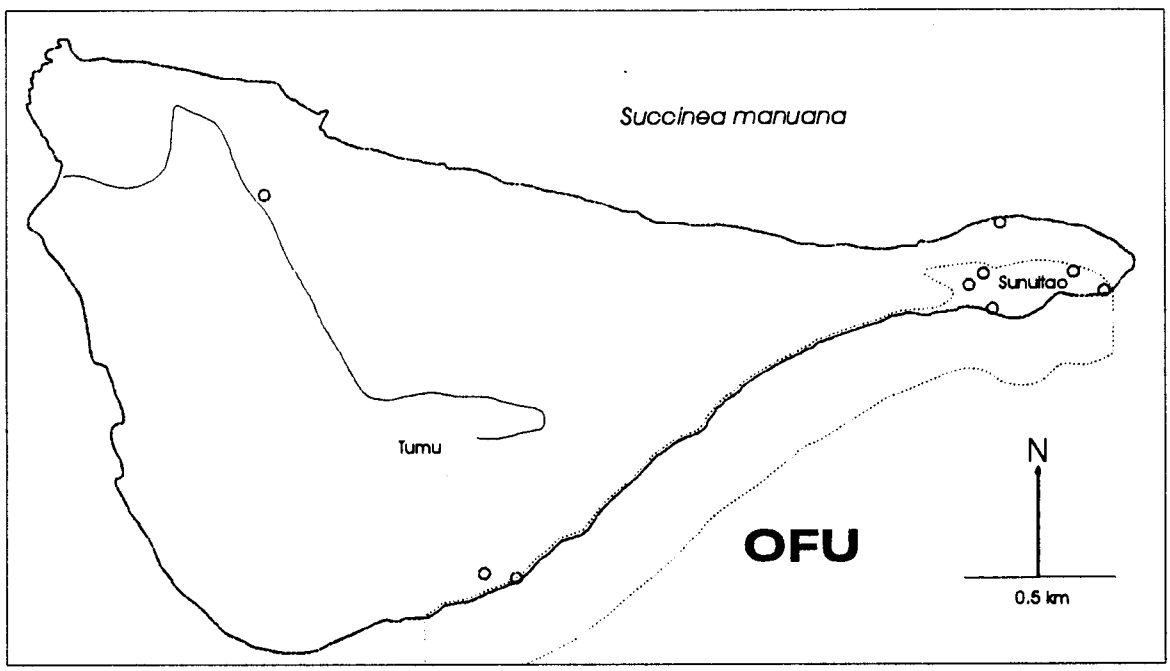

Pleuropoma fulgora
Sunuitao
Tumu
OFU
N
0.5 km

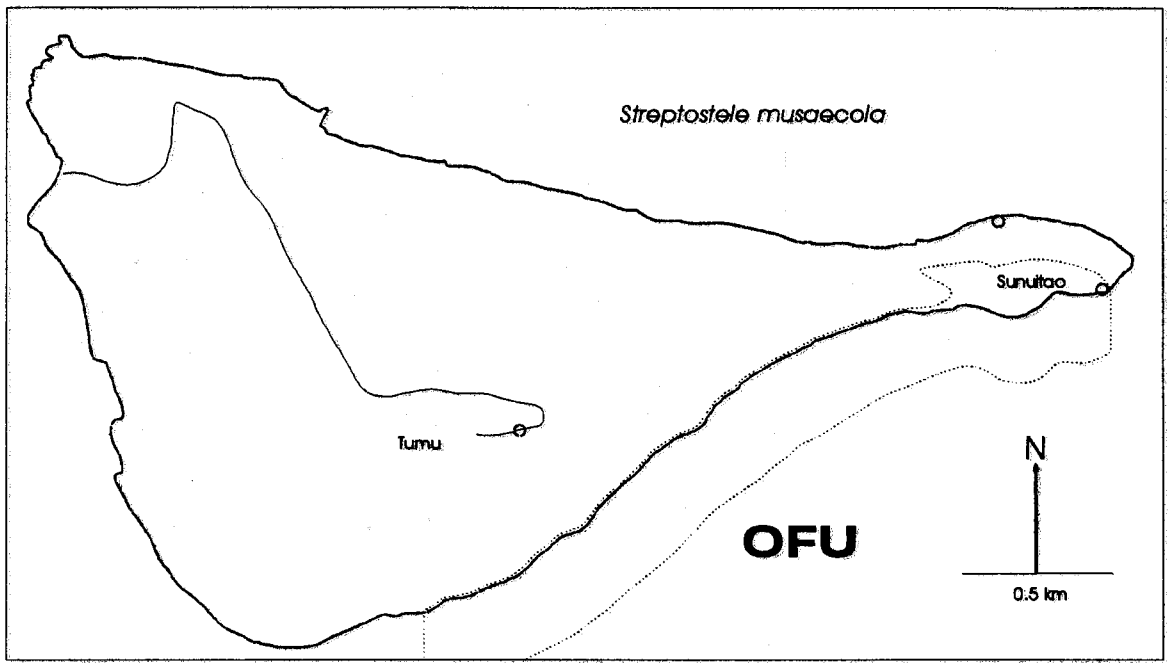

Pupisoma orcula
Sunuitao
Tumu
OFU
N
0.5 km

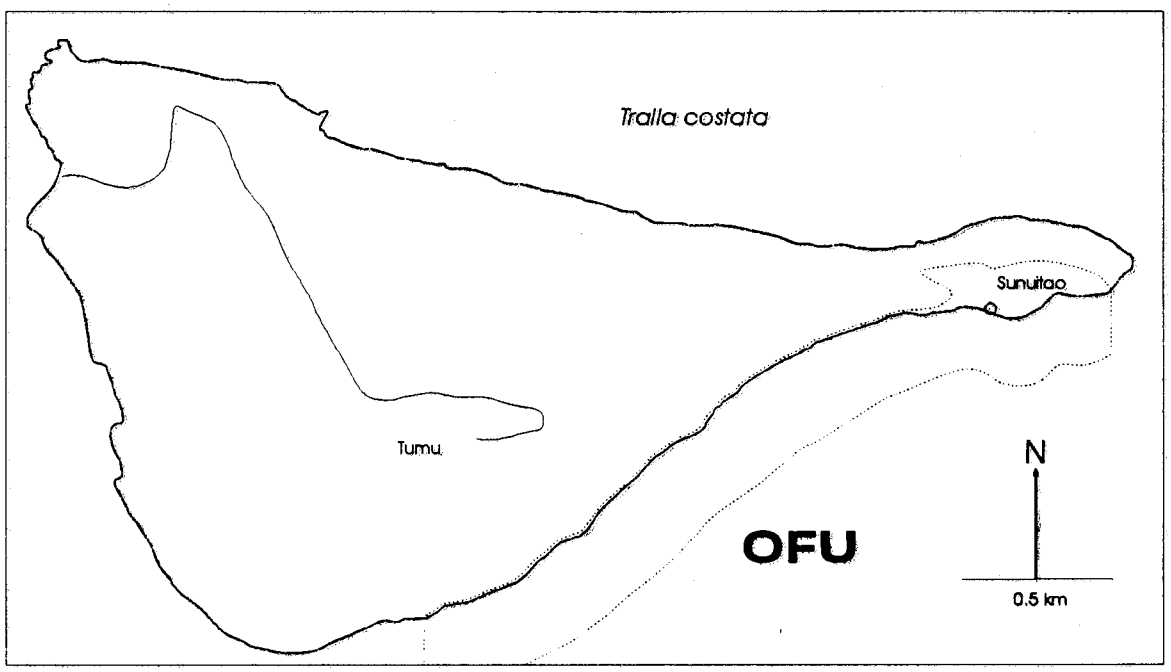

Pythia scarabaeus
Sunuitao
Tumu
OFU
N
0.5 km


Samoana thurstoni
Sunuitao
Tumu
OFU
N
0.5 km


Subulina octona
Sunuitao
Tumu
OFU
N
0.5 km


Succinea manuana
Sunuitao
Tumu
OFU
N
0.5 km


Streptostele musaecola
Sunuitao
Tumu
OFU
N
0.5 km


Tralla costata
Sunuitao
Tumu
OFU
N
0.5 km